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Full Length Research Paper

Evaluation of radiation exposure of eyes, parotid and thyroid gland during panoramic radiography

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The main objective of this study was to evaluate the eyes, parotid and thyroid gland region skin absorbed dose during panoramic radiography with panoramic machine of Oral and Maxillofacial Radiology section of Babol School of Dentistry in Iran. In this research, 273 lif:Mg, Ti thermoluminescent dosemeters (TLDs) (100 LiF:Mg, Ti, harshaw, USA) were used. 90 samples were selected from the patients who referred to the Oral and Maxillofacial Radiology section. For each patient three TLD for eye, parotid and thyroid gland region were carefully applied in each experiment 3 TLD with fixed numbers were used to determine the background radiation. After providing panoramic radiographs, Thermoluminescent signal was read out with a Harshaw 4500 (Harshaw, Bicron USA) reader. Then the data of each TLD number was sent back to us .Mean ± standard deviation was determined by SPSS10 software. Mean ± SD of skin absorbed dose for 90 patients was 0.11 ± 0.075, 0.23 ± 0.15, 0.13 ± 0.079 mg for eyes, parotid and thyroid gland regions respectively. Since Diagnostic Reference level (DRL) of panoramic imaging is unknown in Iran, there is no possibility to compare the current results with DRL. However, it can be stated that the skin absorption dose of thyroid gland in the current study is more than the only reference value of thyroid gland skin absorption dose (0.074 mgy). It can be concluded that an extended study should be done to assess if the decrease of radiation dose without significant reduction of image quality is possible. However there is not a proper reference level to compare the findings, we hope this study play a small role in setting DRL for panoramic imaging in Iran with the help of further studies.

Key words: Radiography, panoramic, thermoluminescent dosimetry, thyroid gland, parotid gland.

INTRODUCTION

Medical exposures are the most important source of public exposure to man-made radiation. Nowadays the lesions detection and disease diagnosis are based on clinical and paraclinic findings. In the past decades, X-rays have been used widely in dentistry (Ribeiro, 2012).

Dental radiology is being extensively used especially after the consolidation of the dental implant technique (Batista et al., 2012). Therefore radiographic findings play an important role. Entrance surface dose (ESD), named skin absorbed dose in current article), and dose-area

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product (DAP) are the most important parameters measured in diagnostic Radiology (Williams and Montgomery, 2000). Due to increasing radiological examinations, patient protection against X-rays is important. Therefore, all national and international forums have specific recommendations to further protection of patients. Being able to accurately assess the radiation dose patients receive during procedures is a crucial step in the management of dose (Zhang et al., 2012).The most appropriate modality that estimate the risk of radiation is effective dose (Ludlow, 2012).

WHAT IS DRL AND ESD?

Since the introduction of the term "diagnostic reference Level (DRL)" by ICRP in 1996 (ICRP, 1996), there have been continuing worldwide efforts to develop and implement DRLs in diagnostic radiology as well as nuclear medicine (Mortazavi et al., 2004; Ann ICRP, 1996). ICRP in its 1996 publication recommends that to set DRLs (Ann ICRP, 1996). While no DRLs are proposed for panoramic radiographies by International Atomic Energy Agency (Mortazavi et al., 2004). Selection of a DRL using a percentile point on the observed distribution of dose for patients should be specific to a country or region (ICRP, 2002; Ann ICRP, 2001). ESD is amount of skin absorbed dose at the entrance point of the X-ray beam.ESD measurement can be performed directly or indirectly. Termo Luminescent Dosimeter (TLD) measures the ESD directly (Faghihi et al., 2011).

WHAT IS THE PROBLEM?

However, in Iran, due to lack of large scale studies, no diagnostic reference levels had been set for X-ray diagnostic procedures. In a comprehensive research project carried out by Asadinezhad M, Bahreyni Toossi MT in 2008, they proposed the first Iranian diagnostic reference levels (Asadinezhad and Bahreyni, 2008; Toosi and Asadinezhad, 2007).

Thus, in most countries, measuring the exact radiation dosage that a patient is receiving during radiological examinations is the main and inevitable program in related radiation safety centers. So every few years the dosage of radiation being received by patients is determined with statistical methods and dosimeters. So proper safety procedures and protection of patients can be applied according to the determined amount of radiation received by patients (Zhang et al., 2012). International Commission on Radiological Protection (ICRP) 60 determined the limit dose for the annual occupational exposure to 50 milli sivret per year. However, this dose is more than the allowable amount of the general population (1 milli sievert per year).

Occupational exposure of personnel should be controlled so that it does not exceed the following limits:

-The average annual effective dose is 20 millisievert (msv) for 5 consecutive years.

Eye lens equivalent dose is 150 millisievert per year and the equivalent dose for the hands and feet, or the skin is 500 millisievert per year (Ann ICRP, 2001; White and Pharoah, 2009a). Since the distribution of the absorbed radiation dose depends on the type of the panoramic device, in present Study, panoramic radiographs has been taken by the device Cranex Tome® (Soredex, Helsinki, Finland) to determine skin dose of eyes, parotid, and thyroid gland regions.

AIM OF STUDY

The main aim of this study was to assess the skin absorbed dose in the eyes, parotid and thyroid gland regions during panoramic radiographies. As in Iran, there is lack of proper guidelines for radiographic exposures. This study helps us to recognize that if decreasing the radiation dose during undergoing this imaging modality is needed. We hope this study will be a step to promote the radiation safety of patients who need X-ray imaging modalities.

MATERIALS AND METHODS

In this research project, 273 thermoluminescent dosimeters (TLD-100, Harshaw, USA) were used. The lithiumfluoride chips (LiF:Mg, Ti) were 3.3 and 0.9 mm and the atomic number is nearly the atomic number of the soft tissue.

The 90 samples were exposed under variable conditions (KVp = 63 to 77, mA = 4, S = 12). TLDs were annealed before using in clinic in TLD laboratory .90 patients who had referred to the Oral and Maxillofacial Radiology section of Babol School of Dentistry in Iran for panoramic radiography attended in this study. We have split the samples into three age groups:

1. Age group 4 to 10 years
2. Age group between 10 to 40 years
3. Age group of 40 years and above

Each chip was sealed in a plastic cover and had a special number. For each patient, 3 TLD numbers on the skin of the eye region (one centimeter away from external cantus of eye on contameatal line), parotid region (one centimeter away from tragus on alatragus line) and the thyroid gland region (on the thyroid cartilage skin in midline of neck) was carefully installed on skin with antiallergenic adhesive tape and numbers were selected randomly. 3 TLD chips with fixed numbers were always

Table 1. Mean ±SD of skin absorbed dose of organs in 90 patients.

Average skin absorbed	d dose of 90 patients (mGy)
Eye mean±SD	0.11 ± 0.075
Parotid mean±SD	0.23 ± 0.15
Thyroid mean±SD	0.13 ± 0.08

Table 2. Skin effective dose of 90 patients.

Average of Skin effective dose of 90 patients *WT=0.01* $E = \Sigma W_T \times H_T$	µsv
Eye	1.1
Parotid	2.3
Thyroid	1.3

Table 3. Mean ±SD of skin absorbed dose of eyes, parotid and thyroid in three age groups.

Average of skin absorbed dose age group 4_10 years		Average of skin absorbed dose age group(10_40years)	Average of skin absorbed dose age group above 40 years
Organ	**mGy**	**mGy**	**mGy**
Eye SD±mean	0.12±0.068	0.1±0.05	0.12±0.10
Parotid SD±mean	0.23±0.13	0.21±0.14	0.23±0.17
Thyroid SD± mean	0.15±0.065	0.14±0.10	0.11±0.66

used to determine background radiation. Three tanks were prepared for the TLD: A storage tank for TLD which do not receive radiation and another storage tank for TLD which receive radiation, and a tank for keeping three backgrounds TLD. Three tanks were always kept out of the x-ray room.

For each age - sex group, there was a specially designed table in which exposure conditions and biographical information of patients was carefully recorded. After providing TLD panoramic radiographs, TLD were calibrated in SSDL laboratory, National Radiation Protection section of Iran Atomic energy department to thermoluminescent signal was read out with a Harshaw 4500 (Harshaw, Bicron USA) reader. Then the data of each TLD number was recorded in a table. Since the aim was to measure the skin dose of organs, the exposure conditions (kvp, mA, S) of each age- sex group were not identical and exposure conditions in the system were set by radiology technologists based on their prior knowledge and experiences. Before starting the research project, no specific training or recommendations regarding the exposure conditions were performed for the radiology technologists to make exposure conditions be completely random .So the Kvp and m As considered independent the variables and the radiation dosage was the dependant variable. Mean ± Standard deviation was calculated with SPSS10 soft ware.

The effective dose was calculated as follow: $E = \sum (WT \times HT)$, E is tissue weighting factor (WT) and (HT) is human-equivalent dose for tissue equivalent dose (HT) is calculated by the equation: $HT = \sum(WR \times DT)$, where WR is radiation weighting factor and (DT) is average absorbed dose measured for that specific organ.

RESULTS

Findings on skin absorbed dose and skin equivalent dose for 90 samples and for three age groups of 4 to 10 years, aged between 10 to 40 years and above 40 years is as follows: Mean ± SD of skin absorbed dose for 90 samples are 0.11 ± 0.075, 0.23 ± 0.15and 0.13 ± 0.08 (mgy) for eyes, parotid and thyroid gland region respectively (Table 1). Mean ± SD of effective dose for 90 samples are 1.1, 2.3 and 1.3 (µsv) for eyes, parotid, and thyroid respectively (Table 2). Mean ± SD of skin absorbed dose for 30 samples aged below 10 are 0.12 ± 0.068, 0.23 ± 0.13, 0.15 ± 0.65 mgy for eyes, parotid and thyroid respectively (Table 3). Mean ± SD of skin absorbed dose for 30 samples aged 10 to 40 are 0.10 ± 0.05, 0.21 ± 0.14, 0.14 ± 0.10, and 0.45 ± 0.098 (mgy) for eyes,

Table 4. Organ effective dose of 90 patients

Organ effective dose of 90 patients $E = \sum W_T \times H_T$		μsv
eye	$W_T = 0.12$	13.2
parotid	$W_T = 0.01$	2.3
thyroid	$W_T = 0.04$	5.2

Table 5. Exposure conditions.

Average of exposure condition for age group 4-10 years			Average of exposure condition or age group 10-40 years			Average of exposure condition for age group above 40 years		
Average age: 9.83 years			Average age: 28.63years			Average age: 52.63 years		
S	mA	Kvp	S	mA	Kvp	S	mA	Kvp
17	10	65	18	10	69	19	9	68

parotid, thyroid, and head and neck respectively (Table 1). Mean ± SD of skin absorbed dose for 30 samples aged above 40 are 0.12 ± 0.1, 0.23 ± 0.17, 0.11 ± 0.066, and 0.46 ± 0.1 (mgy) for eyes, parotid, thyroid, and head and neck respectively (Table 1 and column chart 23). As shown in Table 1, the most skin absorbed dose of 90 cases belongs to the parotid region (0.23 ± 0.15 mgy) and the lowest belongs to the eyes region (0.11 ± 0.075 mgy). Table 4 show the effective dose of organs (eyes, parotid and thyroid gland) for 90 samples. Table 5 shows the average exposure conditions in three separate age groups.

DISCUSSION

Table 2 shows the mean and standard deviation of the data of skin absorbed dose of 90 samples in region of eyes, parotid and thyroid gland in mGy. The mean absorbed dose of thyroid region skin in above data disagrees with the assumption of White SC, Pharaoh MJ in which thyroid gland has the absorption dose of 0.074 mGy (White and Pharoah, 2004). The exposure conditions, type of panoramic machine, number, location and type of dosimeter are the probable reasons for this contravention. Most of the skin absorption dose belongs to parotid (0.23 ± 0.15 mgy) and the lowest refers to the eye region (0.11 ± 0.075 mGy). As is to be expected, in panoramic imaging parotid glands are completely exposed to beams and show a greater dosage in comparison with other two organs receiving secondary radiation. But in comparison of eyes with thyroid gland, both being exposed with secondary radiation, the results show the greater amounts of absorption dose for thyroid due to two factors as follows:

First, there is less distance from the central ray and exposed area to thyroid gland. Because during panoramic radiography, the patient's head is absolutely straight, but the lower jaw and chin are positioned to a slightly lower situation. Another factor related to the anatomic location of the eye and thyroid gland. As we know, panoramic imaging during irradiation, X-ray tube moves behind the patient's head and the two organs (eyes and thyroid gland) get the secondary beams. Considering the difference between the circumference of diameter of head and neck and the thickness of the skull bone in comparison with neck tissue, it is obvious that the skull attracts much more of the secondary X-rays and radiation dose received by the eyes was less than the thyroid, so thyroid absorption dose will be more in panoramic radiography (White and Pharoah, 2009b).

In a research conducted by Manson-Hiny LR, Greer DF (1977) about the dose received by the thyroid during panoramic and cephalometric imaging, the researchers stated that by the use of Barrier collar, only during the cephalometric examination, it is reasonably possible to reduce exposure of thyroid gland (Manson-Hing and Greer, 1977).

In present study, no special protection was used during panoramic radiography for the thyroid gland. In a study conducted by Hayakawa Y and their colleagues in 2001, for dosimetry, two different panoramic machines were used (Hayakawa et al., 2001).

Absorption dose by the use of Orthophos panoramic machine was 5 to 10 Gy region results from tests performed by the use of panoramic devices orthophos was calculated 5 to 10 Gy for region of eye, 63 to 185 Gy for the parotid gland and 14 to 27 Gy for thyroid gland.

Effective dose was calculated 11 µsv with special adults programs and 6 µsv with special children program.

Absorption dose results from experiments with PM2002cc panoramic machine was announced (11 to 21 µgy), (95 to 244 µgy) and (35 to 54 µgy) for eye areas, parotid gland and thyroid gland region respectively.

Results of the present study for skin absorbed dose are 110 ± 75, 230 ± 150 and 130 ± 80 micro gray for eye areas, parotid gland, and thyroid gland respectively.

Effective dose was announced (13.2), (2.3) and (5.2) micro sivret for the eye area, parotid and the thyroid gland respectively.

The major difference between the results of the present study and the above investigation is due to:

1. Use of a child skull with dental age form 4 to 5 years.
2. Use of TLD dosimeters with diameter of 2 mm and a length of 12 mm.
3. Repetition of the panoramic sequence for 10 times.
4. Use children settings for the both devices.
5. Use of dry skull instead of alive patient.

In another study was performed by Gijbels et al. (2005), absorbed dose and effective radiation dose were measured. The effective dose for the patients was calculated 8.1 micro sirvet (only for parotid gland) .They the used the same panoramic machine as our research device. They determined the absorbed dose for thyroid gland 52.2 micro gray (by the use of cranex Excel) (Gijbels et al., 2005; Okano et al., 2009). But in the results of our study, effective skin absorbed dose of the parotid gland, the effective dose of the parotid gland, and the skin absorbed dose of thyroid for 90 samples are 2.3, 2.3 and 130 ± 80 micro gray respectively. As it is obvious, there is a difference between effective dose of parotid gland and the findings of the present study. But overall reasons for the differences are due to:

1. Using phantom containing 100 TLD installed on various sections.
2. This test was performed only 10 times with five different devices.
3. Exposure conditions were identical in each experiment.

In Doyle et al. (2006) study of dose width product (DWP), the quantity recommended for assessment of patient dose for panoramic dental radiography, was determined by comparison of results obtained from 20 orthopantomographic units measured with three techniques: a small in-beam semiconductor detector and X-ray film, a pencil ionization chamber and an array of thermo luminescent dosimeters (TLDs). The DWP for 30% of the units tested exceeded the diagnostic reference dose of 65 mGy mm, recommended by the National Radiological Protection Board (Doyle et al., 2006).

In a comprehensive research project carried out by Asadinezhad M, Bahreyni Toossi MT in 2008, they proposed the first Iranian diagnostic reference levels.

The following seven routine types (14 projections) of X-ray examinations were studied: Antero-Posterior (AP) abdomen, AP cervical spine, Lateral (LAT) cervical spine, AP chest, LAT chest, Postero-Anterior (PA) chest, AP lumbar spine, LAT lumbar spine, AP pelvis, AP skull, LAT skull, PA skull, AP thoracicspine and LAT thoracic spine. Cases considered were hose for which the images were diagnostically acceptable. Patient's entrance surface dose (ESD) was also measured by TLD chips.DRL determined for each imaging modality. The patient dose survey in Iran is still going on with expanding measurements for interventional radiographies, CT scan, mammography and angiography examinations (Asadinezhad and Bahreyni, 2008; Toosi and Asadinezhad, 2007).

In a study was done by Garcia et al. (2008) effective dosages for Veraviewepocs dental panoramic images: analog film, digital, and panoramic scout for CBCT were measured by anthropomorphic phantom loaded with thermoluminescent dosimeters (TLD 100H) at 16 sites located in sensitive organs. The highest value (5.2 musv) was for Veraviewepocs Conventional. The Veraviewepocs Digital (2.7 musv) and Veraviewepocs 3D (2.95 musv) presented low effective doses in the same range. They conclude that the panoramic digital system delivered the least radiation dose. The use of the panoramic scout for cone-beam CT was marginally higher in dose than its 2D counterpart (Garcia et al., 2008; Lorenzoni et al., 2012).

In a study conducted by Gavala et al. (2009) to calculate the effective dose, test was repeated 6 times by the two types using conventional and digital panoramic devices, with the same exposure conditions on a phantom (equivalent to a 47 year old male), with TLD100 (Lorenzoni et al., 2012; Gavala et al., 2008).

Mean ± SD absorption dose was calculated for conventional panoramic Planmeca promax (ma=6, kvp=66, S=16). The results were announced (30 ± 11) mgy, (315 ± 42) mgy, and (60 ± 27) mgy for eyes, parotid gland and thyroid gland respectively. Results of effective dose were announced 3, 9 and 0.02µsv for thyroid gland, parotid gland and buccal skin respectively. Mean ± SD dose of absorption were repeated twice by the panoramic digital device (planmeca PM 2002cc) with exposure conditions of (S = 18, ma = 4-kvp =60 and S = 18, ma = 8 ,kvp = 66).the result was: for eyes (55 ± 10.4), (33 ± 40), for thyroid gland (17 ± 88), (24 ± 50), for parotid gland (4/78 ± 510), (44 ± 130) and buccal skin (33 ± 8.15), (36 ± 26.5)µsv. Results of effective dose with mentioned exposure conditions and above panoramic machine was (4.5 and 2.5), (4 and 15), and (0.02 and 0.04) µSv for thyroid, parotid and buccal skin respectively.

Reasons for the observed difference between the results of above study and the findings of the present study are as follows:

1. Kind of panoramic machines
2. The same exposure conditions for the six test with conventional and digital panoramic devices
3. Using a phantom instead of real patient.
4. Number and location of the TLD
5. Tissue weighting factor was based on the ICPR60 study reported in 1990.

In a related article published by Matsuo A. Et al in 2011 to assess the Absorbed dose and the effective dose of panoramic temporo mandibular joint. They measured the doses received by various organs and calculated the effective doses. They used an anthropomorphic phantom, loaded with thermoluminescent dosimeters (TLD), located at 160 sensitive sites. The dose shows the sum value of irradiation on both the right and left sides. In addition, they set a few different exposure field sizes. The result was: The effective dose for a frontal view in Panoramic TMJ was 11 µsv that for the lateral view was 14 µsv. They recommend that the size of the exposure field in Panoramic TMJ be decreased (Matsuo et al., 2011).

In a related research project performed by Grünheid et al. (2012), dose of a panoramic machine and a cone beam computed tomography device were measured by thermoluminescent dosimeters placed in 20 sites inside a head and neck phantom. Effective doses were calculated using the tissue-weighting factors recommended by the 2007 International Commission on Radiological Protection. The effective doses for digital panoramic were measured 21.5 µsv. They conclude that although CBCT is providing additional diagnostic and therapeutic benefits, also exposes patients to higher levels of radiation than conventional digital radiography (Grünheid et al., 2012).

It is not easy to measure exact radiation dose in studies. The problem arises from the fact that the radiation dose from a panoramic radiograph with a Well-Collimated x - ray beam, is not fixed around the patient and has fluctuation. So the scattered radiation dose is dependent on patient anatomy and the imaging geometry.

More information are available is the result of using 100 TLD on phantom, using different devices and has been obtained under same exposure condition. Therefore, compared with present study and findings, radiation spectrum has more uniform distribution. This is justifying the differences between obtained results in this study and other studies.

As there are major differences in the rate of organs absorption dose in panoramic radiography depending on the type, number and exact location of dosimeters, exposure conditions, annually calibration of devices and the types of devices, and on the other hand (DRL) is still unknown on panoramic radiographs in Iran (Mortazavi et al., 2004; Asadinezhad and Bahreyni, 2008; Toosi and Asadinezhad, 2007), there is no possibility to compare the results with DRL. However, in relation to the thyroid absorption dose during panoramic radiography, it can be stated that present study reports higher rates of dosage for thyroid skin absorption than the only available source of thyroid absorbed dose (0.074 mgy) But it is less than thyroid absorbed dose while conducting radiographs of the cervical spine (5.5 mgy) (White and Pharoah, 2004).So decrease of radiation dose seems to be acceptable and should have be done with this panoramic unit. It can be obtain practically with decreasing the exposure condition (ex:KVp and S). Although the dosimetry investigations are fundamentally physic based, but no one can neglect its importance and practically use of the data it collects for us, as this research indicated the need for decreasing radiation dose. However, as in Iran there is not national DRL for panoramic imaging, it is not obvious reducing the radiation dose that still provides a diagnostically acceptable image quality. It can be concluded that an extended study should be done to assess if the decrease of radiation dose without significant reduction of image quality is possible. However there is not a proper reference level to compare the findings, we hope this study play a small role in setting DRL for panoramic imaging in Iran with the help of further studies.

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