Original

Dosimetry of Occupational Radiation around Panoramic X-ray Apparatus

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ABSTRACT

Background: Panoramic imaging is one of the most common imaging methods in dentistry. Regarding the side-effects of ionizing radiation, it is necessary to survey different aspects and details of panoramic imaging. In this study, we compared the absorbed x-ray dose around two panoramic x-ray units: PM 2002 CC Proline (Planmeca, Helsinki, Finland) and Cranex Tome (Soredex, Helsinki, Finland).

Materials and Methods: In this cross-sectional study, 15 thermoluminescet dosemeters (TLD-100) were placed in 3 semi-circles of 40cm, 80cm and 120cm radii in order to estimate x-ray dose. Around each unit, the number of TLDs in each semicircle was 5 with equal intervals. The center of semicircles accords with the patient's position. Each TLD was exposed 40 times. These dosemeters were read out with a Harshaw Model 4000 TLD Reader (USA). The calibration processing and the reading of dosemeters were performed by the Atomic Energy Organization of Iran.

Results: The mean absorbed dose in three lines of PM 2002 CC Proline was 123.2±15.1, 118.0±11.0 and 108.0±9.1 µSv, (p=0.013). The results were 140.4±15.2, 120.2±10.4 and 111.6±11.2 µSv in Cranex Tome (p=0.208), which reveals no significant difference between two systems.

Conclusion: There are no significant differences between the mean absorbed dose of surveyed models in panoramic imaging by two units (PM 2002 CC Proline and Cranex Tome). These results were less than occupational exposure recommended by ICRP, even at the highest calculated doses.

Citation: Pakravan A. H, Aghamiri S. M. R, Bamdadian T, Gholami M, Moshfeghi M. Dosimetry of Occupational Radiation around Panoramic X-ray Apparatus. *J Biomed Phys Eng*. 2019;9(5):525-532. https://doi.org/10.31661/jbpe.v0i0.466.

Keywords

X-Rays; Radiation Dosage; Radiography, Panoramic; Occupational Exposure

Introduction

The radiographic examination is an important diagnostic method. It is used in all fields of medical services and contributes to the promotion of the health. A certain amount of radiation is inevitably delivered to the patients and population. Panoramic imaging or panthomography is an imaging technique in which tomographic image of maxillary and mandibular arches and surrounding structures can be seen [1]. This method is helpful in the general evaluation of teeth and some other head and neck tissues. Panoramic radiograph provides information about the teeth and supporting bone. It is used to screen for extra teeth, cancer, cysts, premature loss of teeth, teeth fused to tooth eruption path, the bone or abnormally retained teeth, bone pathology, and mandibu-

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Received: 27 October 2015
Accepted: 20 December 2015

lar asymmetry [2, 3]. However, its use is more common [4-6]. Organ equivalent dose both in patients and health care staff, depending on the type of unit is different [7, 8]. Although most research on the estimation of absorbed or effective dose in panoramic radiographies is focused on the patients, it should be considered that the medical staff are also exposed to the harmful effects of radiation, including the implementation of a recommendation for personal dosimeters, radiation protection program and the use of barrier shielding [9]. In previous studies, it was shown that the risk of papillary cancer of thyroid in the female staff of dental care centers was higher [10, 11]. Some cases of skin malignancies are also reported such as squamous cell carcinoma and epithelioma [12, 13]. Most of these cases were among the staff who hold the film in patient's mouth, and this method is not being used now [14]. Due to increasing care of the radiation protection rules, the dentists are less exposed.

The effective dose in dental radiography is relatively lower than general radiography [15]. The average dose for intraoral radiography ranges from less than 1 to around 20 mSv [16, 17] depending on the film or digital sensors used focus skin distance, tube voltage and collimation. The effective dose reported in panoramic radiography ranges from 4 to 30 mSv [18, 19]. According to the previous studies, cancer risk in human population could not be demonstrated at doses below 10 mSv. At this range, the risk remains hypothetic and the linear no-threshold relationship between dose and risk is considered the best practical criterion [20]. An epidemiologic study in Canada, 1951-1987, revealed that the risk of cancer in dentists was not higher than the public [21]. International Commission on Radiologic Protection implies on the limitation of yearly occupational exposure to 20mSV, which is higher than 1mSV for general population [22], and were further revised in ICRP 103, 2007 Publication. As a result of the revisions, the effective dose in dental radiology is estimated to be 32-422% higher because of the recent inclusion of the salivary gland, oral mucosa, muscle, extrathoracic airway and lymphatic nodes in the list of radiosensitive tissues [23, 24]. The dentists are less exposed to radiation, and there is not so much concern about their occupational exposure [8, 14], but studies on this subject are more limited. In a study in Belgium, they calculated the equivalent occupational organ dose 0.18-0.53µGy for thyroid and 0.04-0.38µGy for gonads by using different digital panoramic units in 1 meter [14]. Several types of dosimeters including the thermoluminescence dosimeter (TLD), optical stimulated luminescence (OSL) dosimeter or photoluminescence glass dosimeter could be used to measure the exposure [25].

Radiation exposure and absorbed dose are related to different parameters like the type of units and digital or analogue device [7, 26]. The aim of this study was to determine and compare X-ray absorbed dose around two different panoramic units, PM 2002 CC Proline and Cranex Tome, which are most common in Iran.

Material and Methods

In this observational cross-sectional study, we used 30 TLDs. To carry out this research, 15 TLDs were placed around each unit. Units characteristics are shown in Table 1. For these dosemeters, the minimum detectable dose is 100µSV. They were divided into 3 groups of 5 TLDs, and each group was placed in a 180° arch with the center of patient. Each 3 arches had the same center and were placed in equal distances. Radii of these arches were 40, 80 and 120 cm. TLDs were placed almost at the height of thyroid gland of a person about 170 cm.

The number of exposures to each TLD was 40 which were implemented in 3 days. These exposures were done on the patients of oral and maxillofacial radiology department of Shahid Beheshi University Dental School (Tehran, Iran). 23 men and 17 women were evaluated for their dental problems by PM 2002 CC Proline, while 21 men and 19 women were evaluated by Cranex Tome unit in this period. Mean height of patients for two units was 169.7±12.8 and 170.8±11.6, respectively (t=0.393, p=0.695). In order to record the background exposure beside these units, a person carried one similar TLD for 3 days as a control.

After finishing the exposures, the TLDs were delivered to Atomic Energy Organization of Iran. They were coded and anonymous. TLDs were read out in a Harshaw Model 4000 TLD Reader (USA). The absorbed dose was determined by the area under the brightness curve, related to each LCD unit and reported in μSV.

The data were analyzed by SPSS16.00 (SPSS, Chicago). We calculated means and standard deviations for quantitative data. Comparison between groups and determined distances was done by the analysis of variance for repeated measurements and paired T-test. Then, comparison between the dose of each TLD setting and control TLD was carried out by one sample T-test. Initially, type I error (α) was considered 0.05, but regarding the low number of cases, P<0.1 was also significant.

Results

Quantitative analysis of absorbed dose in both units is listed in Table 2. These data showed that in PM 2002 CC Proline unit, the absorbed dose decreased by increasing distance (F=26.033, p=0.013), while the difference between the first and third rows was statistically significant (p=0.026). These differences in Cranex Tome unit was not that significant (F=2.774, p=0.208).

According to ANOVA, there was a significant difference between three rows (F=0.099, p=0.009). But T-test showed no difference between the same rows of two units. Data are shown in Table 3.

Absorbed dose of control TLD (background radiation) was 105μSV. Comparison of absorbed doses of rows with absorbed dose of control TLD is shown in Table 4 revealing that only absorbed dose of first and second rows of Cranex Tome unit was higher than control TLD at p<0.05; while, at the level of 0.1, there were also significant differences between the first and second rows of PM 2002 CC Proline

Table 1: Characteristics of each unit

Unit	Tube voltage (kV)	Tube current (mA)
PM 2002 CC Proline Planmeca, Helsinki, Finland	80	12
Cranex Tome Soredex , Helsinki, Finland	81	10

Table 2: Descriptive data of absorbed doses (μSv) for each unit: Planmeca and Soredex

Unit	Distance (cm)	Mean (SD)	Median	Minimum-maximum
PM 2002 CC Proline	40	123.2 (15.1)	120	105-145
	80	118.0 (11.0)	110	110-130
	120	108.0 (9.1)	105	100-120
Cranex Tome	40	140.4 (15.2)	145	115-155
	80	120.2 (10.4)	120	110-133
	120	111.6 (11.2)	115	100-125

Table 3: Comparison of absorbed doses of two units (Planmeca and Soredex), according to T test

Level	Levene's test for equality of variances		T test for equality of means	
	F	p	t	p
First	0.039	0.849	1.794	0.111
Second	0.329	0.582	0.326	0.753
Third	0.505	0.498	0.558	0.592

Table 4: Comparison of absorbed doses of each row for two units (Planmeca and Siredex) with absorbed dose of control TLD (105µSv)

Unit	row	t	p
PM 2002 CC Proline	First	2.291	0.055
	Second	2.654	0.057
	Third	0.739	0.501
Cranex Tome	First	5.210	0.006
	Second	3.267	0.031
	Third	1.318	0.258

unit and control TLD.

Discussion

Panoramic radiography with a simple inexpensive and available technology provides a rapid and comprehensive radiographic view of teeth and surrounding tissues [4-6]. While some findings such as maxillary sinus or pathologic dental finding can be missed in the panoramic radiographs [27], many dentists only use it for dental implant assessment [28]. It is a common imaging technique in general dental practice providing a good view of the entire mandible including the condylar region. Panoramic radiography is commonly used by many for mandibular fractures [29]. In the recent clinical studies, it is shown that it can play a critical role in the identification and evaluation of osteoporotic patients or people with low BMD by dentists [30, 31]. So, there is a growing use of the panoramic radiography [32], and millions of these radiographs are taken annually for treatment 2 and diagnostic1 [28]. Previous studies have demonstrated that there are differences in absorbed dose of patients as well as dentists and dental staff [8]. It seems that these differences exist in dentists and dental staff to some extent. According to the International Commission on Radiological Protection (ICRP), annual effective dose for occupational exposure was 50mSV that is much higher than 1mSv for general population [22], and as a result of the revisions, the effective dose in dental radiology is estimated to be 32-422% higher [23, 24]. Dosimetry is not a simple task to implement. These difficulties originate from the fluctuations in the exposure by a well-collimated X-ray beam around patients [33]. So, absorbed radiation dose is associated with the anatomy of patient and geometry of scan. While limited trials have been conducted in this subject, Gijbels et al. calculated the occupational dose in digital panoramic units [8]. In that study, the maximum organ equivalent dose (thyroid and gonad) in 1 meter distance was 0.60µGy and the maximum effective dose was 0.10µGy. In Belgium, each dentist makes about 500 panoramic imaging each year. According to these, an effective dose for thyroid was estimated about 5-15µSv and for gonads 5-40µSv. These figures are related to the type and model of units [7, 8, 34].

We conducted the current study by two units. This study showed that absorbed dose in three rows (40, 80 and 120 cm) was not so different. The structure of the imaging room affects the results. Structure of the room and stuff used in walls and roofs is effective in absorption, transportation and reflection of radiation.

The highest amount of absorption was seen in one of the samples of the first row of Cranex Tome unit (155µSV), so maximum absorbed dose during a year (52 weeks in a year and 5 days of work in a week) is 13.4mSV that is less than annual effective dose for occupational exposure (20mSV in a year). In this case, the effective dose reported in panoramic radiography varied from 4 to 30 mSv [18, 19]; ionizing radiation risk for females is relatively higher than males because of the differences in position and size of radiosensitive organs [35].

Similar researches to this study are very rare [8], and some researchers have been carried out on aim groups like patients [7, 34]. Most of the results with similar cases are the results of intraoral radiographies and not the panoramic radiographies [36].

In this study, the irradiated model was at the approximate level of thyroid gland. As we know, the effective dose of occupational exposure for the organs is different. Equivalent dose of organs in thyroid and gonads level is comparable but it is a few higher for thyroid [8]. If the figures are multiplied at the weighting factors of each organ [21], the effective dose of gonads will be higher (this factor is 0.2 for gonads and 0.05 for thyroid).

In this study, the absorbed dose in points 1 and 5 - at the ends of irradiation range at PM 2002 CC Proline unit - was higher, while the same results were not absorbed in Cranex Tome unit. In the studies of Gijbels et al. [7, 8], the calculated dose in 5 points was different. We also observed the same results in PM 2002 CC Proline group. These results regarding to the rotation of system, is reasonable [7, 8, 22, 37]. On the other hand, regarding to the significance of 0.1, the absorbed dose in the third row was higher than the first row in both systems. With the increase of distance from 40 cm to 120 cm, absorbed dose reduces to 12.3% and 20.5% in the systems. Even without any shield, keeping the 2m distance from the source in proportion to 1m and on the basis of inverse square law reduces the absorption by 75%.

Background radiation in each year is about 3.6mSv [38], and it is different in geographical locations. In this study, the background radiation dose in control group was calculated 105µSv in 3 days. In Cranex Tome unit, absorbed dose -in row 1 and 2- was higher but it was not significant for PM 2002 CC Proline unit and it is because of limited sample size. If the significant level was 0.05 instead of 0.1, this difference will be significant for PM 2002 CC Proline and it means that mean absorbed dose in the first two rows is higher than the background dose. But in the third row of both groups, the difference is not significant.

It should be considered that absorption dose in extra-oral radiographs is less than a full-mouth radiograph which is due to intensifying screens.

Conclusion

According to our study the absorbed dose in surveyed models reveals no significant difference in two systems, Cranex Tome and PM

2002 CC Proline. This amount -even in highest doses- was less than occupational exposure and decreases with the increase of distance. These figures had no significant difference with background dose. Nevertheless, primary radiation protection principles should be considered.

Conflict of Interest

None

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