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Doses in Dental Radiography

Dosis en Radiografía Dental

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ABSTRACT: Thermoluminescent dosimeters were used to measure the absorbed dose in a patient undergoing a dental radiography. The X-ray unit was working to 70 kV and 8 mA. In order to avoid the exposure to the actual patient, a phantom was used. Side and front dental radiography were obtained where the entrance surface, thyroid, and lens absorbed dose were measured by using type 100 thermoluminescence dosimeters (TLD100). TLDs were calibrated using an electronic dosimeter. The entrance surface doses were 2.78 mGy in the cheek and 2.71 mGy in the chin. In the side exposure, the absorbed doses in lens and thyroid were 0.04 mGy. In the front radiography, the doses were 0.03 mGy in the lens and 0.14 mGy in the thyroid. These values are lower than the reference values recommended internationally and by the Mexican regulations.

KEY WORDS: dose, x-ray, dental X-ray, thermoluminescent dosimeters.

INTRODUCTION

In 1895, by serendipity, W. C. Roentgen discovered the X-rays obtaining the first radiographic image. The feature to see the internal structure of the human body detonated the use of X-rays in health sciences (Seibert, 2004; Turner, 2005; Prasad *et al*., 2004). At that time, the photon interaction with matter and the effects of X-rays in the cells were unknown and the first victims of the exposure to X-rays were among persons operating the equipment. In 1910 were reported several cases of “radiation burns", and some deaths related with the exposure to X-rays, promoting the start of radiological protection (Marshall & Keene, 2007).

Currently, X-rays are used for diagnosis and treatment of many diseases. Worldwide, the use of X-rays for diagnosis contributes to the highest dose of exposure to artificial radiation in humans due to the large number of radiographs. The information provided by the X-ray image allows having more elements for a good diagnosis; however, the exposure to X-rays includes a risk due to the harmful effects to cellular level which may have somatic and genetic consequences (Prasad *et al*.; Turner; Aquino *et al*., 2010; Vega-Carrillo *et al*., 2011).

Chest x-ray and dental intraoral exams are the most frequent studies performed in the radiology service since the X-ray images allow better diagnosis; also the performance of medical procedures can be followed (Looe *et al*., 2006; Alcaraz *et al*., 2012). However, in the community of dentists, there is a perception that the doses due to dental radiography are practically null (Vassileva, 2002; Meghzifene *et al*., 2010).

The radiation dose depends upon the amount of X-rays photons and their energies, and health risk depends on the age of the person, the absorbed dose, and the organs or tissue-type exposed. Therefore, it is important to determine the dose levels during the use of X-rays as a technique for the diagnosis (Cuenca, 1997).

Aiming to establish diagnostic reference levels in intraoral radiography Izawa *et al*. (2017) determined the entrance dose of 1063 patients y three X-ray units, working to 60 kVp and 7 mA. For incisors, maxillary images the mean dose was 1.56 ± 0.27 mGy, and for mandibular molars, the average dose was 2.42 ± 0.33 mGy.

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In Mexico, dental radiography is used by all dentistry students aiming to learn how to obtain the image and to make a proper diagnosis, in this learning process the student plays the roles of the dentist, patient, and observer. However, there is not personal dosimetry, neither a radiation survey in this process. Therefore, it is important to determine the doses in this particular use of X-rays (Gaona & Enríquez, 2004; ICRP, 2007; Loya, *et al*.).

Loya *et al*. determined the absorbed dose and the effective dose in a group of dentistry students. Aquino *et al*. measured the doses involved in different dental radiographs. Although these doses are relatively small, the result in the collective dose becomes important and cannot be ignored, due to the large number of tests that are performed (Lee *et al*., 2010).

In the dental clinical area, the harmful effects of exposure to ionizing radiation have not been demonstrated, but it is known that continuous exposure at low doses can result in long-term effects due to the cumulative nature of the dose by ionizing radiation (ICRP, 2007).

In Mexico, there is an official standard (NOM, 2006) that establishes the definitions, requirements, design, operation, and monitoring procedures that must be followed in any facility having any X-ray equipment. Among the included requirements is the determination of radiation leakage. For quality control, the standard points out the need to know the Kerma in air on the entrance surface of the patient's body (ICRU, 2005). For the radiation protection of radiation workers, the standard defines the need to use personal dosimetry. In order to protect the patient, the standard includes the guidance levels of the doses on the entrance surface of different types of radiographs; in the case of dental and periapical radiographs, these values are 5 and 7 mGy per radiograph respectively (IAEA, 2002; ICRP 2017).

In the dentistry academic unit of the Universidad Autónoma de Zacatecas, students in their preparation, should familiarize them with the X-ray equipment and learn the techniques to obtain X-ray images. In this process, students take different roles: patient, dentist, and observer without any personal dosimetry or radiation survey. The objective of this work was to determine the dose in patients undergoing dental X-ray.

MATERIAL AND METHOD

The study was carried out in the academic unit of dentistry in the Guadalupe campus, of the Universidad Autónoma de Zacatecas, in Guadalupe, Zacatecas in Mexico. The multidisciplinary clinic of Zacatecas (CLIMUZAC) of this academic unit has several fixed X-ray equipment, a mobile unit, and a unit for panoramic radiographs. The CLIMUZAC is a space where dental health services are provided to the public and is a learning space for dentistry students in training.

The X-ray equipment that was used was a CORAMEX, SA brand, model COR-70/8-03. This X-ray tube works to 70 $\pm$ 10% kV with a maximum current of 8 $\pm$ 15% mA, having a 2 mm-thick aluminum inherent filter and the focal point is 0.8 mm (GM, 2018).

The measurement of the dose was made with thermoluminescent dosimeters of the TLD100 type (Eliyahu *et al*., 2018). Before use, the dosimeters were heated to 400 ºC for 1 hour in order to erase them. The reading of the TLDs was done with a reader Harshaw TLD model 3500 (TFS, 2018), and the glow curves were obtained from 50 to 300 oC under a nitrogen atmosphere with a temperature gradient of 10 ºC/s (Singh & Kainth 2018).

The calibration of the TLDs was done with the X-ray equipment exposing the TLDs to 27.5 cm from the target of the X-ray tube. Twenty-eight TLDs, in sets of 4, were used for the calibration and 8 TLDs were used to measure the background. TLDs were exposed to X-rays from 1, 2, 3, 4, 5, 6, and 7 shots of the equipment working to 70 kV and 8 mA. The dose was measured with a RaySafe model ThinX RAD monitor that yields different parameters when the X-ray equipment is on (Iwawaki *et al*., 2018; RaySafe, 2018).

Once exposed TLDs were read. The readouts of 4 TLDs exposed to X-rays were used to calculate the average; this was corrected by the mean readout of those TLDs used to measure the background. The background-corrected readouts averages were correlated with the dose given by the ThinX RAD monitor using weighted least squares (Vega-Carrillo, 1989).

For the taking of X-rays, a head phantom was used to represent the patient and the dose was measured in thyroid, crystalline and in the entrance surface of the X-ray beam, for this 4 TLDs were placed in polyethylene containers that were fixed at the phantom, another group of TLDs was used to measure the background. For the study, two types of radiographic images were selected, one lateral and one frontal, in each one 10 shots were made, with the same operating conditions, with an exposure of 0.6 seconds per shot.

For lateral radiography, the entrance surface was the cheek, while the entrance surface on the frontal radiograph was the chin, as shown in Fig. 1.

Figure 1. Patient phantom with the TLDs being exposed to dental X-rays

Once irradiated the TLDs were read from the

Fig. 1. A Patient phantom with the TLDs being exposed to dental X-rays (Side Exposure).

Fig. 1. B Patient phantom with the TLDs being exposed to dental X-rays (Frontal Exposure).

individual readings of the TLDs of each container the average was obtained, Li, which were corrected by the average of the readings of the TLDs of the container used to measure the background radiation, B, as displayed in equation 1.

$$RC_i = L_i - B$$

The uncertainty associated with the corrected readings was obtained by propagating errors of the standard deviation of the readings of the TLDs of each container (sL) and that of the TLDs used to measure the background (sB), as shown in the equation 2.

$$\sigma_{RC} = \sqrt{\sigma_L^2 + \sigma_B^2}$$

After having adjusted to a linear function the corrected responses and the value of the Kerma obtained in the calibration, in equation 3 the adjusted linear function is shown that allows correlating the corrected reading of the TLD in nC (RC), with the value of the Kerma in air (Ka) in µGy.

$$Ka = -(0.4772 \pm 9.99\%) + (111.6 \pm 1.11\%)\ RC$$

The correlation coefficient is $r^2 = 0.9997$

The average values of the corrected thermoluminescent responses were converted to Kerma in air values using equation 3, and the Ka values were converted to absorbed dose.

RESULTS

The values of the dose absorbed in the patient on the lateral and frontal radiographs are shown in Tables II and II.

Table I. Doses in lateral radiography.

Position of TLDs	Dose (mGy / shot)
Cheek	2.778 ± 0.317
Eye lens	0.039 ± 0.005
Thyroid	0.040 ± 0.005

Table II. Doses in frontal radiography.

Position of TLDs	Dose (mGy / shot)
Chin	2.709 ± 0.394
Eye lens	0.031 ± 0.004
Thyroid	0.137 ± 0.015

DISCUSSION

The values shown in Table I are of the same order of magnitude for the lens and the thyroid since the distances of both to the entrance surface of the beam are similar. In Table II, the dose received in the chin is also greater, and the values in thyroid and crystalline are lower. Unlike the doses of the lateral radiograph, the values for crystalline and thyroid are different, since the thyroid is closer to the chin receives a higher dose than the crystalline lens that is at a greater distance from the entrance surface of the beam.

The mean dose during mandibular molars X-ray imaging has been reported as 2.42 ± 0.33 mGy (Izawa *et al*.), this value is consistent with 2.78 ± 0.32 mGy measured in the cheek.

The values reported in Table I and II for the skin of the entrance surface respectively are lower than 9.97 mGy/shot reported by Loya *et al*. for an exposure of 0.6 sec, nevertheless, the dose reported for the thyroid is of the same order of magnitude as that of this work. The difference is attributed to the fact that they used equipment that operates at 50 kV and the X-rays have less energy than those produced by a 70 kV device, therefore a larger current must be used, thus a large dose is absorbed on the entrance surface.

Our input surface dose values are greater than the 0.7 mGy reported by Aquino *et al*. whose equipment has the same voltage and current parameters as the one used in this work, however the firing time they used was different from the 0.6 sec used in our work and this is probably the reason for the difference.

During a radiographic sampling, the guidelines indicate that the dose should be less than 7 mGy, and as shown in Tables I and II, in neither case does the dose exceed this value.

CONCLUSIONS

During dental X-rays, the highest dose is recorded at the entrance surface of the beam. Part of this radiation is scattered (Compton scattering) by air and skin reaching some sensitive organs such as the thyroid and lens whose dose depends on the orientation of the x-ray unit and the distance between the organ and the entrance surface.

Using thermoluminescent dosimeters on a head and neck female phantom the dose in the entrance surface, lens and thyroid were measured when the phantom was exposed to dental X-rays in lateral and frontal exposition.

For both expositions the entrance dose and the dose in the lens are very similar, however, the dose in thyroid is 3.4 times larger when a frontal dental radiography is taken in comparison to the lateral dental radiography.

In none of the cases are more than 7 mGy established as a guideline level.

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RESUMEN: Mediante dosímetros termoluminiscentes se ha medido la dosis absorbida en un paciente sometido a una radiografía dental. La unidad de rayos X se operó a 70 kV y 8 mA. Para evitar la exposición de un paciente real se usó un maniquí al que se obtuvieron dos radiografías dentales, una frontal y otra lateral. Los dosímetros termoluminiscentes que se usaron son del tipo 100 (TLD100) que se calibraron con un dosímetro electrónico. Las dosis en la superficie de entrada del haz en el paciente fueron 2,78 mGy en la boca y 2,71 mGy en el mentón. En la exposición lateral la dosis en el lente y en la tiroides fue de 0,04 mGy, mientras que en el disparo frontal las dosis fueron 0,03 mGy en el lente y 0,14 mGy en tiroides. Los valores de la dosis son inferiores a los valores orientativos señalados en las recomendaciones internacionales y la legislación mexicana.

PALABRAS CLAVE: dosis, rayos X, radiografía dental, dosímetros termoluminiscentes.

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