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Research Article

Radiation Dose to the Parotid and Thyroid Glands in Intraoral Radiography

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Abstract: ***Background:*** Intraoral radiography is requested to evaluate the dentition or oral cavity. During the procedure scatter radiation reach close structures like the parotids glands. The study is aimed to determine the radiation doses to the parotid and thyroid glands. ***Materials and method:*** A prospective cross-sectional descriptive study design was adopted from March 2018 to March 2019 with 55 patients undergoing intra-oral radiography at dental clinic of Living Word Mission Hospital, Aba, using thermo luminescent dosimeters (TLDs). The TLD was used to measure the Entrance Surfaces Doses (ESDs) to the parotid gland by placing it the skin over the parotid. The doses were read and mean ESD of all patients calculated. ***Result:*** The results indicated entrance surface doses (ESD) ranged between 0.13mGy to 2.76mGy for the parotid and 0.11mGy to 3.92mGy to the thyroid. The overall mean ESD±SD to the parotids and thyroid were 1.07±0.62mGy and 1.05±0.82mGy respectively. The mean ESD±SD for males were 1.10±0.63mGy and 1.08±0.88mGy for parotid and thyroid glands respectively, while that for females were 1.02±0.61mGy and 1.00±0.74mGy for the parotids and thyroid glands respectively. No statistically significant difference was found between these means. ***Conclusion:*** The doses obtained were lower than the documented threshold that could cause significant damage to the parotid gland, not undermining stochastic effect of radiation. This study will assist in setting diagnostic reference level for intraoral radiography in Nigeria.

Keywords: Radiation Dose, Parotid Gland, Thyroid Gland, Intraoral Oral Radiography, thermoluminescent dosimeters.

INTRODUCTION

In dental radiology, the intraoral periapical technique is one of the most frequently used procedures of dental radiology that allows the detection of a variety of dental anomalies such as caries, dental trauma and periodontal lesions, while exposing patients to relatively low doses of radiation (Tolentino *et al.*, 2011). The intraoral radiography is an exploratory technique that consists of placing within the mouth of the patient radiography films of different sizes that are exposed from the outside by an X-ray machine (American Dental Association Council on Scientific Affairs, 2006). Intraoral periapical radiography serves to explore two to four teeth, from the crown to the apex, the periodontal space and the surrounding bone tissue (Azorín *et al.*, 2015).

The measurement of the dose received by patients is considered an important factor in the quality control in medical radiology (Brenner *et al.*, 2003 & Dula et al 1998). One of the most important parameters in diagnostic radiology is the surface entrance dose (Williams & Montgomery, 2000), so it is important to determine the entrance dose received by patients in intraoral radiographic examinations performed with different imaging systems (Eun-Kyung ,*et al.*, 2012). The entrance surface dose (ESD) is a measure of the dose absorbed by the skin at the point of entrance of the X-ray beam (Sadeka *et al.*, 2018). This determination could be made by direct measurement using thermoluminescent dosimeters (TLD) or ionization chambers or calculated indirectly. The method recommended for measuring entrance dose is thermoluminescent dosimetry due to the specific characteristics of this type of dosimeters (Azorin *et al.*, 2015).

The thyroid gland, one of the most radiosensitive organs is frequently exposed to scattered radiation (Robinson *et al.*, 2019) and occasionally to the primary x-ray beam during dental radiography. Although many authors support the theory that the risk

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of radiation carcinogenesis to the thyroid gland during dental radiography is minimal when compared with other diagnostic imaging examinations and other global factors, a number of epidemiological studies have provided evidence of an increased risk of thyroid tumours from dental radiography (Rush & Thompson, 2007; Tolentino *et al.,* 2011). Being able to accurately assess the radiation dose that patients receive during procedures is a crucial step in the management of dose (Jibiri *et al.,* 2017). If the dosage is higher than expected, this indicates serious health risk to the operator and recipient and this often evolves from problems in the optimization of either equipment or procedures or both. The principal concern in radiological protection is to ensure that the examinations are conducted with radiation doses that are As Low as Reasonably Achievable to meet clinical practice (Jibiri *et al.,* 2017).

Most of the studies on dose evaluation in dental radiography are based on standardized calculation phantoms which are the physical or mathematical (virtual) representation of the human body and neglect the variance of the patient size or sex (Farrier *et al.,* 2009). In physical phantoms, organ and tissue-equivalent doses can be determined by averaging over many TLD measurements, inserted in a certain phantom volume. However, the definition of organ volume is often difficult because of the irregular shape of organs. In addition, the energy dependence of the TLD response can also complicate the interpretation of measured data because the energy distribution of the radiation field inside the phantom is usually unknown. Although in mathematical human phantoms size and form of the body and its organs are described by mathematical expressions, these are still rather stylized models of the human body and of its organs (Kramer *et al.,* 2004 and Tolentino *et al.,* 2011).

Several dose measurements survey was previously carried out with respect to patients' dosimetry in Nigeria. But most of these surveys were conducted on patients for conventional radiographic examination with a very little survey on dental radiography (Jibiri *et al.,* 2017). Although the radiation risk of intraoral radiography is generally low, there are delayed somatic effects of low doses of x-radiation. Furthermore, dental radiography was associated with an increased risk of salivary glands tumours and thyroid cancer (Zhang *et al.,* 2012).

According to the International Commission on Radiation Protection (ICRP) recommendations, the selection of a diagnostic reference level (DRL) should be specific to a country or region. In Nigeria, due to lack of large scale studies, no diagnostic reference levels have been set for intraoral radiography. Hence the there is a need to provide a reference data for the establishment of regional and/or national diagnostic dose reference levels (Diagnostic Reference Level) for thyroid and parotid glands in intraoral radiography.

MATERIALS AND METHODS

A prospective cross sectional descriptive study design was adopted for the study at the Dental Clinics, of Living Word Mission Hospital, Aba, Abia State. Patients presenting for intraoral periepical radiological examinations during the period of study.

A convenience sampling method was adopted. The sample size was derived from the target population using Taro Yamane formula (Yamane, 1967):

$$n = \frac{\mathrm{N}}{1 + \mathrm{N}(e)^2}$$

Where n= sample size; N= Population of study; e= level of precision (0.05).

The sample population, N will be calculated from the number of patients that registered for intraoral periepical x-ray within the period of study. From the hospital record, 60 patients reported for the radiological examination. Hence, the sample population is 60.

$$n = \frac{60}{1 + 60(0.05)^2}$$

n = 60/1.15 = 52

The sample size is fifty two (52). This was increased to fifty five (55) to have a good representative of the study population and increase the level of confidence.

Ethical Consideration

In line with Helsinki Declaration, ethical clearance was obtained from the Faculty of Health Science and Technology Research Ethics Committee. The research was explained to the subjects and written informed consent obtained from each subject before their participation in this study.

METHODOLOGY

An AMS dental x-ray machine is a digital sensor machine and 70 kVp Digital (with timing from 0.1millisecond to 2.9sec) – adjustable Round with 20 cm cone length specifications shown in table 3.1 was used as a source of radiation exposure. The machine manufactured 2010 in Germany was installed in the hospital in 2015.

Thermoluminescent dosimeters (TLD-100, Harshaw, USA) was used for the measurement of entrance skin dose. All the dosimeters used in this study were calibrated and annealed (in order to remove any residual signals in them) at the Centre for Energy and Research, Nigerian Nuclear Regulatory Authority, Zaria.

A calibrated radiation monitor (Radalert 100) from National Institute of Radiation Protection and Research (NIRPR) was used to check the natural

background radiation level at the dental clinic. Stadiometer and Hanzon emperor weighing scale were used for height and weight measurement respectively.

METHOD OF DATA COLLECTION

Measurement of dose on the skin of the thyroid and parotid glands was made using thermoluminescent dosimeters (TLD-100, Harshaw, USA). The TLDs were mounted on adhesive tape and place on the skin over the thyroid gland and the parotid gland before exposure. The TLDs were carefully removed after the exposure and placed in a black cellophane protective bag and later sent to the research institute for reading. All TLDs were read out with a Harshaw 4500 (Harshaw, Bicorn USA) reader at the Centre for Energy and Research, Zaria.

Data Analysis

All variables obtained were collated and documented into tabulated data sheet and analyzed in accordance with the study objectives. Variables such as age, height, weight and calculated BMI were obtained from each patient and documented before exposure to radiation. The data was categorized and analyzed to obtain the mean, range and standard deviation using Statistical Package for Social Sciences (SPSS) windows version 22.0 statistical software (SPSS Inc. Chicago, Illinois, USA).

The results obtained are presented in tables. A descriptive statistics was used to measure the mean, range and standard deviation. A paired sample t-test was done to compare the means between males and females. The test of association was performed using Pearson correlation. A p-value of less than 0.05 was considered statistically significant for tests of association.

RESULTS

55 patients of which 35 are males and 20 females who presented for intraoral periapical radiographic examination at the dental clinic of Living Word Mission Hospital Aba, Abia State were studied. Details of the results are presented in the tables below in line with the objectives of the study.

The overall mean age of participants was 35.34±13.58years while 34.46±14.60years and 36.90±11.78years are the mean ages for males and females respectively (see table 1).

The overall mean entrance surface doses (ESDs) to the parotid and thyroid glands were 1.07±0.62mGy and 1.05±0.82mGy respectively with a range of 0.13mGy to 2.76mGy and 0.11mGy to 3.92mGy for the parotids and thyroid glands respectively as described in table 2. Whereas the mean entrance surface doses (ESDs) to the parotid and thyroid glands in male and female patients were (1.10±0.63mGy; 1.08±0.88mGy) and (1.02±0.61mGy; 1.00±0.74mGy) respectively (table 3).

Table 1: The overall mean entrance surface doses (ESDs) to the parotid and thyroid glands in all patients

PARAMETER	N	Mean ± SD	RANGE	P-value	t-value
AGE	55	35.34 ± 13.58	6.00-85.00		
BMI	55	25.51 ± 5.39	15.25-45.35		
PAROTID DOSE	55	1.07 ± 0.62	0.13-2.76		
THYROID DOSE	55	1.05 ± 0.82	0.11-3.92	0.881	0.150

Table 2: The mean entrance surface dose (ESD) to the parotid and thyroid glands in male and female patients

Parameters	Males		Female	
	RANGE	Mean ± SD	RANGE	Mean ± SD
AGE	6.00-85.00	34.46±14.60	20.00-61.00	36.90 ±11.78
BMI	15.25-31.63	23.67 ±4.24	20.34-45.35	28.74 ±5.76
PAROTID	0.13-2.76	1.10 ± 0.63	0.31-2.70	1.02 ±0.61
THYROID	0.35-3.92	1.08 ± 0.88	0.11-2.66	1.00 ±0.74

Table 3: Comparison of the mean entrance surface dose (ESD) between male and female patients

Group	Male	Female	P-value	t-value
PARATID DOSE	1.10 ± 0.63	1.02 ± 0.61	0.911	0.112
THYRIOD DOSE	1.08 ± 0.88	1.00 ± 0.74	0.921	0.100

Table 4: Relationship between the parotid and thyroid doses with the patients' anthropometric variables

Parameters	Parotid dose versus anthropometric variables		Thyroid dose versus anthropometric variables	
	R-value	P-value	R-value	P-value
AGE	0.138	0.316	0.118	0.389
BMI	0.003	0.982	0.046	0.738
GENDER	-0.079	0.568	-0.021	0.877
WIEGHT	0.066	0.635	0.146	0.291
HEIGHT	0.017	0.902	0.158	0.255

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5: Comparison of radiation dose values with the proposed diagnostic reference value of 7mGy for intraoral radiography by International Atomic Energy Agency (IAEA, 1997)

GROUP	N	Mean ± SD	P-value	t-value
Overall Parotid Mean Entrance surface dose (ESDs) mGy	55	1.07±0.62		
proposed diagnostic reference value of (7mGy) (standard)	55	7.00±1.55	0.000	26.199
Overall Thyroid Mean Entrance surface dose (ESDs) mGy	55	1.05±0.82		
proposed diagnostic reference value of (7mGy) (standard)	55	7.00±1.55	0.000	24.99

DISCUSSION

X-rays are widely believed to cause malignancies, skin damage and other detrimental effects. Radiation induced cancer is widely believed to be a dose dependent phenomenon (Geijer, 2001). Justification of actions, optimization of protection and dose limits for individuals are the main principles of the general radiation protection system (Ishiguchi, 2001).

The overall mean age of the patients was 35.34±13.58years with mean ages of 34.46±14.60 years for males and 36.90±11.78years for females. The patients sent for the intraoral dental radiography were diagnosed with various oral conditions such as dental caries, periodontal diseases, dental trauma and oral tumours which require intra-oral radiographic examination at the dental clinic of the hospital.

The analyses showed that the overall mean entrance surface doses (ESDs) to the parotid and thyroid glands in the patients were 1.07±0.62mGy and 1.05±0.82mGy respectively. The values of the ESDs ranged from 0.13mGy to 2.76mGy and 0.11mGy to 3.92mGy for the parotids and thyroid glands respectively. Whereas the mean entrance surface doses (ESDs) to the parotid and thyroid glands in male and female patients were (1.10±0.63mGy; 1.08±0.88mGy) and (1.02±0.61mGy; 1.00±0.74mGy) respectively.

Comparison of the radiation dose with the proposed diagnostic reference value of 7mGy for intraoral radiography by International Atomic Energy Agency (IAEA, 1997) showed a statistically significant difference between the IAEA proposed diagnostic reference value and the overall mean values obtained in this study (parotid (1.07±0.62mGy) and thyroid 1.05±0.82mGy) glands.

The results obtained in the present investigation was very low when compared to the proposed provisional reference level of 3.5mGy entrance surface dose for intraoral radiology in the study by Gonzalez *et al.,* (2001). In their study (Gonzalez *et al.,* 2001), data was collected from over 300 intraoral x-ray facilities using thermoluminescent dosimeters. The overall range of doses in this work was also far less than the 7mGy proposed reference level for diagnostic intraoral radiography by International Atomic Energy Agency (IAEA) but falls within the range of 0.01mGy to 0.40mGy for the distribution of Entrance Skin Doses (ESDs) measured at the centre of the beam on the patients' skin in intraoral radiography obtained by IAEA.

The results from this study were slightly higher than those from a recently reported study at the University College Hospital, Ibadan, Nigeria where results indicated that the entrance surface doses (ESD) ranged between 0.0447mGy to 0.3898mGy to the thyroid and 0.0467mGy to 0.4164mGy to the parotids. The mean ESD±SD to the thyroid and parotids for male were 0.1798±0.081 and 0.2197±0.081mGy with the female patients 0.1957±0.084 and 0.2280±0.113mGy respectively.

However, the mean entrance surface doses for males and females in this study were slightly lower

compared with 1.173mGy for females and 1.380mGy for males as reported by Mortazavi *et al.,* (2004). The absorbed doses obtained in this study were also less in comparison to other reference doses such as in the UK, with 2.5mGy reference dose for bitewing exposure at 70kVp using E-speed film and 5.0mGy at 50kVp (Jibiri *et al.,* 2015) but fairly within the Canadian reference ESDs values of 1.09-1.44mGy for intraoral examinations at 70kVp (Jibiri *et al.,* 2015).

The slight disparities arising from the index study and others might be due to the type of intraoral machine used, cone length and positioning, exposure conditions such as tube current, tube voltage, exposure time and focus film distance, the types, sensitivity and speed of films used and the placement and accuracy of TLDs.

Spearman correlation analysis was used to demonstrate the relationship between the entrance surface doses and the patients' anthropometric variables. The result showed that when the mean age, weight, height and BMI of the male patients were correlated with the entrance surface doses to male patients there was no significant positive correlation ($p>0.05$). Also when the mean age, weight, height, and BMI of the female patients were correlated with the entrance surface doses to female patients there was no significant positive correlation ($p>0.05$). However, when the parotid and thyroid glands doses of both genders were correlated there was no significant negative correlation ($p>0.05$).

In the recent past, global attempts that were made at ensuring radiation safety in dental radiography include use of digital systems, thyroid shields and fastest possible films, preferably F-films and careful patient selection for radiography (Jibiri *et al.,* 2015).

CONCLUSION

The mean and range of entrance surface doses to the parotids and thyroid glands of patients who undergone intraoral radiography at the dental clinic of Living Word Mission Hospital, Aba, Nigeria were lower than proposed level set by IAEA. However it should be noted that experimental and epidemiological data do not support the proposition that there is a threshold dose of radiation below which there is no increased risk of cancer (ICRP, 2007).

In Nigeria, due to lack of large scale studies, no diagnostic reference levels have been set for dental radiographic procedures. Therefore, this study will assist in setting Diagnostic Reference Level (DRL) for intraoral radiographic imaging in Nigeria.

Recommendation

We recommend similar nationwide studies to set the diagnostic reference level for intraoral radiography in Nigeria.

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