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An Estimate of Radiation Dose to the Lens of the Eyes, Parotid Gland, and Thyroid Gland in Dental Panoramic Radiography

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ABSTRACT

Introduction: Dental panoramic radiography (DPR) is one of the most frequent diagnostic X-ray procedures, the application of which is currently on a growing trend. During DPR, several radiosensitive tissues, such as the lens of the eyes, parotid gland, and thyroid gland, contribute to the radiation field, and it is necessary to monitor their received dose. The aim of this study was to evaluate the radiation dose to the lens of the eyes, parotid gland, and thyroid gland in patients undergoing DPR at Lorestan Province, Western Iran.

Material and Methods: This cross-sectional study was performed on 180 patients of both genders referred to DPR at two most crowded hospitals in Khorramabad, Iran, namely Tamin-e Ejtemaei (TE) and Shohada-ye Ashayer (SA) hospitals. The radiation dose measurements were carried out using LiF (Mg, Cu, P) thermoluminescent dosimeters (TLDs). To measure the absorbed dose received by the lens of the eyes, parotid gland, and thyroid gland in each patient, five sets of three TLDs, wrapped in a thin plastic bag, were positioned over each eyelid and the anatomical position of the parotid and thyroid glands. The TLDs were read within 24 h of exposure.

Results: The mean absorbed dose received by the lens of the eyes, parotid gland, and thyroid gland were obtained as 155, 160, and 72 µGy for the TE Hospital, respectively. These values were obtained as l24, 558, and 56 µGy, respectively, for the SA Hospital. The results revealed a statistically significant difference between the organs located outside and inside the primary beam in terms of the absorbed dose (P<0.001).

Conclusion: The absorbed dose received by the lens of the eyes and thyroid gland was generally lower than the values reported in similar studies. Nevertheless, the absorbed dose received by the parotid gland in the SA Hospital exceeded the recommended dose reference level of 400 µGy in DPR.

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Introduction

Dental panoramic radiography (DPR) is one of the most frequent diagnostic X-ray procedures frequently requested by dentists to address a variety of dental pathologies [1, 2]..The DPR is a modified type of tomography, which provides a two-dimensional (2D) and broad anatomical view of the teeth, maxilla, mandible, temporomandibular joints, and relevant facial structures on a single image [1, 3].The DPR is more beneficial, especially for patients suffering from oral diseases, in addition to disable and uncooperative patients [2]. It is also used to assess growth and development in children [4]. There has been a remarkable increase in the number of patients referred for DPR, particularly after the inception of implant techniques [5].Accordingly, DPR systems have been user-friendly both for the patients and dentists.

In spite of the immediate benefits of dental X-ray procedures, the use of these approaches is accompanied by some limitations and potential health risks. The DPR is associated with the exposure of the radiosensitive organs located at the head and neck areas (i.e., including the lens of the eyes, parotid gland, and thyroid gland)to ionizing radiation [6, 7].This is a major concern as ionizing radiation carries potential health risks, such as increasing the lifetime risk of developing cancer[4].When discussing the health risks associated with DPR, the risk of developing parotid and thyroid cancers[8]and leukemia [4], and inducing genotoxic effects on buccal epithelial cells is of particular concern[9].

Although the risk of a singular DPR in an individual patient is very low, it should not be underestimated due to its wide frequency [3, 8].Therefore, it is necessary to ensure that the patient radiation dose is kept as low as reasonably achievable. One requirement to establish this legislation is that the authorized bodies set the diagnostic reference levels (DRL) for clinical practice [10, 11].Available evidence shows that there are broad variations in the radiation doses received by the patients for the same type of radiological examination [6].Therefore, it is required to optimize diagnostic radiology examinations so that

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radiation doses received by the patients are commensurate with the clinical purposes.

In 1990, the International Commission on Radiological Protection (ICRP) encouraged the authorized bodies to set DRLs that best meet their specific needs [6].The DRL is determined through the third quartile of the mean entrance surface dose (ESD) distribution for a population of patients. It is intended to prevent the unnecessary radiation doses to patients that do not contribute to medical diagnosis [4, 6, 11-15].The DRL is not a radiation dose limit but a guideline to manage and optimize the radiation dose received by the patient during a given radiological procedure [11, 12].A DRL value of 65 mGy.mm² in terms of dose width product has been reported [16].

Patient dosimetry measurement and following the established DRL values are crucial steps in the optimization of the radiation dose received by the patients [8].With this background in mind, the present study was conducted to evaluate the radiation dose received by the lens of the eyes, parotid gland, and thyroid gland in patients referred to two general hospitals of Khorramabad, Iran, for undergoing DPR.

Materials and Methods

Ethical Consideration

This study was approved by the Ethics Committee of Lorestan University of Medical Sciences, Khorramabad, Iran (IR.LUMS 2017/315). In line with the ethical principles of research, written informed consent was obtained from the patients/parents before irradiation.

Study Population

This cross-sectional study was performed on 180 patients within the age range of7-60 years, referred to two of the most crowded hospitals in Khorramabad, Iran, namely Tamin-e Ejtemaei (TE) and Shohada-ye Ashayer (SA), for undergoing DPR from June to December 2016. The patients were selected randomly from a much larger population. Averagely, 60 and 40 patients referred to the SA and TE hospitals, respectively. The stable patients who were referred for DPR and consented to participate in the study were included in the study. The recorded data included age, weight, height, body mass index (BMI), as well as the exposure parameters, such as applied potential (kVp) and current-time product (mAs).The DPR was carried out for each patient, and dosimetry was performed.

Exposures

The digital panoramic units used for this study were Villa, model OPX-105 (max kVp: 85, max mAs: 10, total filtration: 2.5 mm Al), installed in 2011 at the TE Hospital and CRANEX, model Soredex (max kVp: 85, max mAs: 10, total filtration: 2.5 mm Al), installed in 2013 at the SA hospital. These units have recently been calibrated by the local quality control team. Patients were positioned and exposed following the protocols routinely used in the clinical departments without being subjected to extra-radiation.

Dosimetry and Thermoluminescent Dosimeter Placement

Dose measurements were carried out using cylindrical lithium fluoride thermoluminescent dosimeters (LiF: Mg, Cu, P; Radiation Dosimetry TLD, Hangzhou Freq-Electronic Control Technology Ltd, China), commercially known as TLD GR-200. These TLDs have a small size (dimension of 3.2×3.2×8.9 mm) and are tissue-equivalent. Prior to the study, the TLDs were calibrated to provide the dose in milligray (mGy).

Following the literature [6, 12, 15], the TLDs were irradiated with the diagnostic X-rays of 70kVp and 20 mAs, used in DPR. The TLDs were calibrated against a known exposure measured by a 6-cm ion chamber and Radcal monitor (model 9015).According to the manufacturer's protocol, before and after each application, the TLDs were annealed at 245°C for 10 min and then cooled to 35°C. A calibrated Harshaw 3500 TLD Reader (Thermo Fisher Scientific, USA) was used to anneal and read the TLDs.

We read the TLDs within 24 h of exposure [17] and then the absorbed dose received by each organ of interest was calculated by averaging the readings of the three TLDs in each batch. During the study, a set of three TLDs was kept separately and considered as controls to record the background radiation. To measure the absorbed dose received by the lens of the eyes, parotid gland, and thyroid gland in each patient, five sets of three TLDs were positioned over each eyelid and the superficial anatomical position of the parotid (below and in front of each ear canal) and thyroid glands (the anterior neck, spanning between the C5 and T1 vertebrae, inferior to the thyroid cartilage of the larynx), followed by performing the exposure.

Statistical Analysis

Analytical and descriptive statistics were performed in SPSS software, version 20.0 (SPSS Inc., Chicago, IL, USA). The categorical and continuous variables were presented in percentage and mean±SD, respectively. Independent sample *t*-test was used to compare mean values between the organs of interest. Spearman's rho test was used to evaluate the correlation of radiation dose received by each organ of interest with exposure parameters and patients' age and BMI. A p-valueless than 0.05 was considered statistically significant.

Results

Table 1 shows the characteristics of patients and exposure parameters in both hospitals under study. The mean absorbed doses received by the lens of the eyes, parotid gland, and thyroid gland in the TE Hospital were obtained as 155, 160, and 72 µGy, respectively. These mean values were estimated at24, 558, and 56 µGy in the SA Hospital, respectively (Table 2).

Table 1. Characteristic of patients and exposure parameters in the hospitals under study

Hospital	Mean ± standard deviation					
	Age (year)	Weight (kg)	Height (cm)	BMI (kg/cm^2)	kVp	mAs
TE	30.1±12.6[a]	67.3±12.6[b]	166.2±10.6[c]	24.2±4.1[d]	70±0[e]	9.5±0.1[f]
SA	32.8±14.8[a]	65.8±17.4[b]	163.1±15.2[c]	24.3±3.8[d]	64.8±4[e]	6±4.2[f]

[a, b, c,d] P>0.05;[e, f]P<0.001

BMI: body mass index, TE: Tamin-e Ejtemaei, SA: Shohada-ye Ashayer

Table 2. Mean absorbed dose received by the lens of the eyes, parotid gland, and thyroid gland during dental panoramic radiography in the hospitals under study

Hospital	Mean ± standard deviation		
	Lens of the eyes (µGy)	Parotid gland (µGy)	Thyroid gland (µGy)
TE	155±39[a]	160±47[b]	72±16[c]
SA	24±19[a]	558±98[b]	56±21[c]

[a, b] P<0.001; [c] P>0.05

TE: Tamin-e Ejtemaei, SA: Shohada-ye Ashayer

The results revealed a significant difference between the hospitals in terms of the mean absorbed dose received by the lens of the eyes and parotid gland (P<0.001), as well as the applied kVp and mAs (P<0.001). However, no significant difference was observed regarding the thyroid gland dose.

The radiation dose received by the organs of interest was significantly higher in female patients than in male patients, except for the thyroid gland dose in the TE hospital. The applied mAs showed a direct correlation with the absorbed dose received by the lens of the eyes and parotid gland. Nonetheless, no significant correlation was observed for the thyroid gland. The enhancement of kVp resulted in a lower absorbed dose to the lens of the eyes and parotid gland; however, it was not statistically significant (P>0.05). Moreover, no statistically significant relationship was obtained between all dose measurements and the patients' age and BMI (P>0.05).

Discussion

Consistent with our findings, previous studies have emphasized that during panoramic radiography, the parotid gland receives the highest absorbed dose in comparison to the lens of the eyes and thyroid gland [6, 7, 18, 19]. This can be attributed to the anatomical position of the parotid gland that lies in the primary beam. The lens of the eyes and thyroid gland located outside the primary beam received radiation dose mainly due to scattered radiation [6, 7].

In our study, the mean absorbed doses received by the lens of the eyes, parotid gland, and thyroid gland were 89.5, 359, and 64 µGy, respectively. These values are inconsistent with the values reported by Mashood et al. for the same organs(110, 230, and 130µGy, respectively)[7].This discrepancy maybe due to the variation in the patients' size, exposure parameters, number, location, and type of TLDs, as well as the panoramic units used in these studies.

In line with our study, Mortazavi et al. [4] found no correlation between patients' age and the absorbed dose received by the thyroid gland. As depicted in Figure 1, female patients received higher radiation in comparison with male patients (except for the thyroid gland in the TE Hospital). These differences were more pronounced for the lens dose in the TE Hospital and also for the parotid gland in both TE and SA hospitals. Similarly, Chaparian et al.[3] reported that the overall cancer risk from dental X-rays was higher for female patients than for male patients.

As indicated in Table 1, the TE Hospital used higher kVp as compared to the SA Hospital. In addition, the absorbed dose received by the parotid gland was statistically lower in the TE Hospital than in the SA Hospital. Although the enhancement of kVp is advocated as a well-recognized dose-optimization strategy in dental X-rays, it should not be forgotten that increasing the kVp may decrease the image contrast [4].

The thyroid gland is among the radiosensitive organs that contribute to radiation absorption from scattered radiation during DPR. According to Jibiri et al.[8], dental radiography has the potential to increase the risk of parotid tumors and thyroid cancer. In the present study, the mean absorbed dose received by the thyroid gland was 56 µGy which is relatively consistent with 71 and 74 µGy reported by Mortazavi et al. [4] and White et al.[20], respectively. However, it is in contrast with the value reported by Mashood et al. (130 µGy) [7].

There is a wide variation in patient radiation dose for the same type of radiological procedure. According to Beneyto et al. [21], the absorbed doses from dental panoramic systems can vary by a factor of 200. Accordingly, DRL has been recommended to optimize the patient received dose [12]. The ESD is the dose absorbed by the skin tissue at the entrance point of the beam, backscatter included, and a well-established quantity to monitor the DRL.

Given that the parotid gland is an organ at risk that is directly irradiated during panoramic radiography, it is the preferred organ for considering the received entrance surface dose (ESD) [7].According to our results, the ESD of the parotid gland was obtained as 160 µGy in the TE Hospital. This value was obtained as 558 µGy in the SA Hospital, which is higher than the recommended DRLs reported for Khorasan, Iran (400 µGy) and Madrid, Spain (530 µGy) [22].

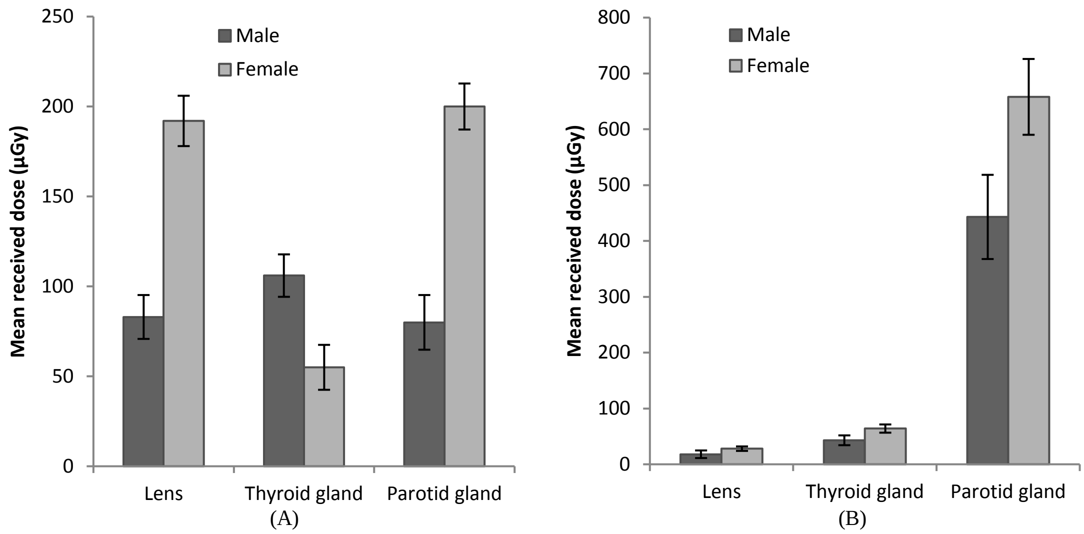

Figure1. Mean absorbed dose received by the lens of the eyes, parotid gland, and thyroid gland in A) the Tamin-e EJtemaei Hospital and B) Shohada-ye Ashayer Hospital according to patients' gender

Although it was expected that the use of digital rather than analog panoramic units would offer the possibility of reducing patients' absorbed doses [23],the absorbed dose received by the parotid gland was higher in this study (which used digital units)than the dose reported by Bahreyni-Toossi et al. [6] using analog units. This may be due to the incorrect use of digital systems. Therefore, dose optimization seems to be necessary.

With the assumption of using the best practice, the lifetime risk of fatal cancer following the performance of DPR is estimated to be in a range of 0.21-1.9 per million of population [21].Nevertheless, it can be increased when using non-optimized practices. Undergoing repeated DPRs and other X-ray modalities is an added concern. Currently, four panoramic units in governmental hospitals and 24 units in private institutes are in use in Khorramabad with averagely500 patients per month, having an annual number of 168,000 DPRs.

The results of our study, performed in two hospitals of Khorramabad, may not be generalizable to all regions of the country. Therefore, more studies are required to ascertain the amount of radiation dose received by the organs at risk during DPR. Implementation of radiation dose surveys and following the local DRL values may be viewed as significant health and safety issues. Our study can serve as a baseline needed for deriving local DRLs for DPR in our province. The main limitation of the present study was the lack of cooperation on the part of some patients.

Conclusion

The absorbed doses are particularly influenced by variations in the exposure parameters and anatomical location of the interested organs. The parotid gland receives the highest absorbed dose (ESD) during DPR. The absorbed dose received by the lens of the eyes and thyroid gland were generally lower than the values reported in similar studies. Nevertheless, the absorbed dose received by the parotid gland in the SA Hospital exceeded the recommended DRL of 400 µGy in DPR. Radiation dose optimization in the SA Hospital seems to be an urgent necessity.

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