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Assessment of Absorbed Radiation Dose of Some Soft and Hard Oral Tissues after Panoramic and Cone Beam CT Radiograph

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Assessment of Absorbed Radiation Dose of Some Soft and Hard Oral Tissues after Panoramic and Cone Beam CT Radiograph

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ABSTRACT

Purpose: The goal of the this study is to measure absorbed dose of oral tissues such as oral mucosa, salivary gland and bone after exposure to ionizing radiation through panoramic radiograph and cone beam CT. **Subjects and Methods:** about 50 Egyptian patients were selected in this study who were referred to the department of oral medicine, periodontology, oral diagnosis & radiology, Faculties of Dental Medicine, Al-Azhar university for panoramic or cone beam examination for various dental purposes. Patients were divided into two groups (25 patients each). First Group was subjected to panoramic examination and the second one was subjected to cone beam examination. The systems used were a Planmeca Viso CBCT and Orthopantomogram OP-100 panorama. Assessment of the patient radiation dose was done by thermo-luminescent dosimeter (TLD) on the patients. The absorbed radiation dose is then recorded. Data was then analyzed, and statistical calculations were performed. **Results:** The absorbed radiation skin doses ranged between (130 μGy, 2817.8 μGy) in panorama and (327.99 μGy, 11994 μGy) in CBCT for one exposure. When digital panoramic unit and CBCT were compared, panoramic imaging is 25-37% of CBCT. Parotid gland and oral mucosa absorbed the greatest radiation dose for all panoramic and CBCT patients. CBCT radiation doses are considerably higher than those of digital panoramic unit. **Conclusion:** The prospective benefits of CBCT in maxillofacial disciplinary are undoubted; but, it is important that their use be totally justified above conventional technique before they are done.

KEYWORDS

Absorbed dose, radiation, panorama, CBCT.

- Paper extracted from Master thesis titled “Assessment of Absorbed Radiation Dose of Some Soft and Hard Oral Tissues after Panoramic and Cone Beam CT Radiograph”

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INTRODUCTION

Utilizing X-rays in dentomaxillofacial examinations have a significant function in observing sickness progress and measuring therapy effectiveness. Doing dentomaxillofacial radiologic inspections causes radiation to the parotid gland, eye lens, and thyroid gland by reason of scatter irradiation or direct coverage to the X-ray beam. Since an enormous amount of cured patients are children as well as young adults, not any exposure to X-rays can be considered free of hazard, specially aimed at children. So, the health specialists have the duty to make sure that the diagnostic significance is maximized, and the radiation doses are retained as low as reasonably achievable [1,2].

Dental diagnostic imaging in the last century was ruled by way of radiographs, which are 2D pictures of 3D structures, by accompanying overlap as well as distortion. By the overview of CBCT, there were advantages in the technology interest. This was in the form of 3D reestablishment, a 1:1 ratio that permit reliable dimensions, improved image quality, the probability for craniofacial picturing, besides lesser radiation dosages related to Computed Tomography [3,4]**.** The selection of the modality is a very main concern as the exposure of radiosensitive structures is affected by the radiological modality used and the particular procedure applied. However, the panoramic radiography has been extensive considered as the examination technique of choice for a range of dental and maxillofacial uses. Though, this 2D prediction provides no data on bone thickness and offers less comprehensive info than bite-wing or intraoral radiographs, panoramic radiography suggest detailed picture of serious anatomical structures, and rapid outline of the dental arches [1,5,6].

Furthermore, because of inappropriate patient standing as well as suboptimal image quality, panoramic radiography can result in diagnostic mistakes in a major amount of cases [7]. Three-dimensional material is necessary, once hazards of misdiagnosis and therapeutic doubts are present. Computed tomography permits very quick data achievement with brilliant image resolution of the dental structures, skull base and facial bones. Because of its easy availability and small price, CBCT is now done for a huge amount of dental and maxillofacial uses, for example imaging of impacted teeth, pre-operative implant planning, assessment of endodontic pathology and cysts[3,8,9]. The modern meta-analysis and valuation on CBCT gives dose estimation of imaging CBCT units. Even though numerous publications have compared the radiation doses of panoramic radiography and CBCT, these articles have mostly concentrated on certain tissue radiation exposure otherwise have compared radiation exposure centered on protocols covering dissimilar anatomical regions [10-12].

The present study aim was to measure absorbed dose in the oral tissues such as oral mucosa, salivary gland and bone after exposure to ionizing radiation through panoramic radiograph and cone beam CT.

SUBJECTS AND METHODS

In the present study, fifty patients who had referred to the department of Oral Medicine, Periodontology, Oral Diagnosis and Radiology, Faculty of Dental Medicine, Al-Azhar University, for panoramic and cone beam examination for various dental purposes as implant placement and orthodontic treatment. Their ages raged between 20 and 50 years old, over the period (10/11/2018 - 29/1/2020). Prior to any procedure, all subjects will be informed about the nature, and benefits of their participation in the study. Research ethics committee approval of the faculty of dental medicine for girls was obtained (Code OMPDR-108-3b). We have split the samples into two groups according to technique of radiographic examination, each group had 25 patients. One was subjected to panoramic examination and the other, cone beam examination. Patients were selected according to inclusion criteria: 1) healthy patients with no systemic condition according to modified Cornell index, 2) patients who didn't receive radiotherapy and were excluded 1) pregnant and breastfeeding women, 2) patients who can't tolerate or CBCT as young child, the trauma victim, the handicapped patient or elderly patients who unable to stand for the duration of the image, 3) patients who can't provide the consent. Thermoluminescent dosimeters (TLD-100, Harshaw, USA) were used. The lithiumfluoride chips (LiF:Mg, Ti) were 3.2×3.2×0.9 mm^3. TLDs were annealed in TLD laboratory earlier using in clinic. Orthopantomogram OP-100 panoramic machine that was used with exposure parameter (current of 16 mA and voltage of 75 KV and duration of exposure 17.6 seconds). The CBCT used in the examinations was Planmeca Viso G7 (current of 32 mA and voltage of 100 KV and duration of exposure 19.4 seconds) (medium field of view 6-11 cm).

Every chip had a special number and was sealed in a plastic cover. 4 TLD numbers was used, for each patient. The 1st one on the skin of the zygoma region (one centimeter below external canthus of the eye). The 2nd on the parotid region (one centimeter away from tragus on alatragus line). The 3rd on the cheek (on the half distance of a line between tragus of the ear and corner of the mouth), and the 4th on the upper lip (between nose and vermillion border at site of root of upper central) as in figure 1. Each one was cautiously fixed on skin by antiallergenic adhesive tape also numbers were selected haphazardly. The single TLD in every group were retained in its chosen position for the examinations totally, to minimalize the difference in the assessment of tissue-absorbed dose. To define background radiation, one TLD chip with fixed number was always used. Two containers were ready for the TLD: A storing container for TLD which do not take radiation plus additional storing container for TLD which take radiation. These containers were reserved out of the x-ray chamber all the time. By means of dosimeters located all over the skin of the face and head where the major beam entered, the dose then was independently measured. In lab in Radiation Protection department of Nuclear and Radiological Regulatory Authority (ENRRA), TLD were calibrated. By a Thermo Harshaw 6600 plus reader, the thermoluminescent signal was read out. At that time the data of every TLD number was documented.

Figure (1) TLDs were cautiously fixed on skin by antiallergenic sticky tape

By multiplying the tissue weighting factor (WT) by the mean absorbed dose at the irradiated zone, the effective dose (E) expressed in μSv was calculated. As well as summed over the totally organ/tissue exposed through this equation

$$E = \Sigma WT \times HT.$$

As defined by the ICRP in 2007 [(13)] that is shown in table (1), the tissue weighting factors denotes the relative radio-sensitivities of the tissue as well as the involvement of that tissue to whole hazard. The danger to the entire body had to be stated by the effective dose (E), it give a general signal of the level of harm to healthiness from the exposure. As defined by the ICRP, the effective dose was at that point calculated for the parotid gland, zygomatic bone, oral mucosa and upper central tooth.

Table (1) *Tissue weighting factors as demarcated by ICRP 2007*[13]

Tissue weighting factors	
Organ	**WT**
Oral mucosa	0.12
Salivary glands	0.01
Bone surface	0.01
Tooth	0.01

WT= tissue weighting factor.

Statistical analysis

Then and there Data was analyzed, statistical calculations were done with Statistical Package for Social Science (SPSS), to define the continuous variables of the differences between the means were tested by whichever the F otherwise t tests, the mean +/- SD were used. Relations among exposures (dose and the position under this investigation) were tested by calculating the coefficient of variation. At P<0.05, Differences was considered significant.

RESULTS

Panoramic radiography as well as CBCT have commonly been used in dental clinics for above ten years. The comparison between both of them was done in the current study regarding the absorbed dose of radiation in different site of oral tissues. This study showed that the mean and standard deviation of the absorbed skin dose using panoramic radiography and CBCT was established to be higher in parotid gland and oral mucosa respectively (1578.89±725.64 μGy, 2442.83±2805.45 μGy). The difference was statistically significant as regard the mean in the panoramic radiography (P-value=0.0263), and not significant in the CBCT (P-value=0.156). The absorbed radiation skin doses ranged between (130 μGy, 2817.8 μGy) in panorama and (327.99 μGy, 11994 μGy) in CBCT for one exposure. (Table 2)

In the current study, the position of Parotid gland revealed the uppermost absorbed radiation dose value, followed by oral mucosa as well as zygomatic bone. The lowest value was that for the upper central tooth (Fig. 2). Parotid gland and oral mucosa showed the highest absorbed dose value except in one patient which had a very high value of the upper central tooth position (Fig. 3)

The absorbed radiation skin doses were importunately greater in case of the CBCT compared to the panorama in the present study. The degree was found to be 1.5 to 4.3 times as shown in table (3).

Table (2) *Comparison between the Mean and Standard Deviation of the Absorbed Radiation Skin Dose (μGy) using Panoramic Radiography and CBCT*

	Panoramic radiography				CBCT			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Upper central tooth	399.05	184.22	130.33	1625.90	1626.81	1002.94	339.2	3675
Zygomatic Bone	599.05	202.01	182.53	1364.20	1558.16	1775.37	327.99	8360.9
Oral Mucosa	562.71	225.46	133.01	2160.60	2442.83	2805.45	446.8	11994
Parotid gland	1578.89	725.64	263.79	5205.20	2409.14	1647.08	446.8	5089.4
P-value	0.0263				0.156			

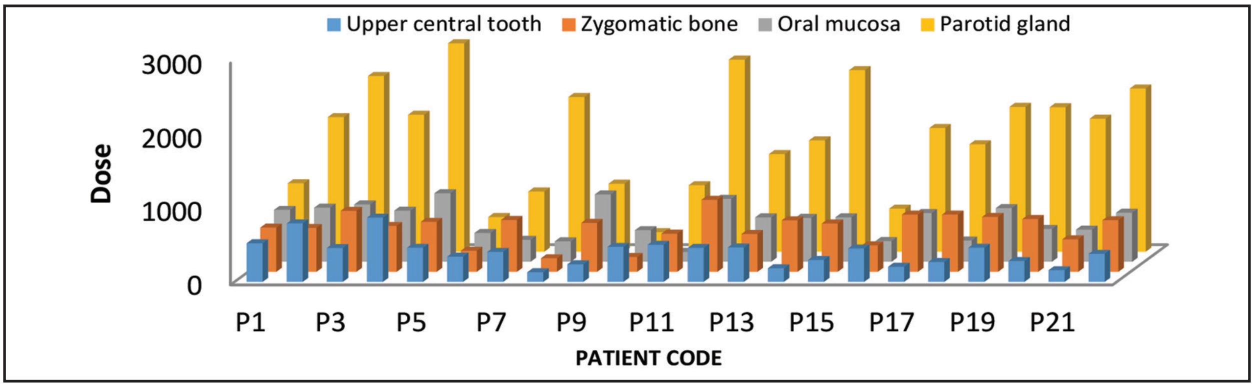

Figure (2) The Absorbed Dose of Radiation by using Panorama Imaging at Different Positions on the Patient.

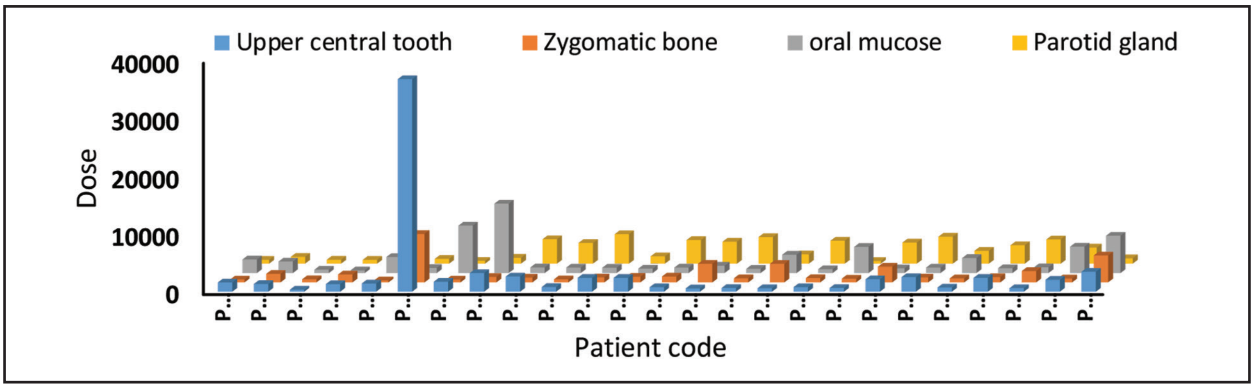

Figure (3) The Absorbed Dose of Radiation by using Cone Beam CT Imaging at Different Positions on the Patient.

Table (3) *Comparison between the Panoramic and Cone Beam CT Radiograph Effective Radiation Dose (µSv) Calculated from the Average Results.*

	Effective Dose (µSv)		
Position	**Panoramic radiography Mean Dose (µSv)**	**CBCT Mean Dose (µSv)**	**CBCT / Panorama (ratio)**
Upper central tooth	3.99	16.27	4.08
Zygomatic bone	5.99	15.58	2.6
Oral mucosa	67.53	293.14	4.34
Parotid gland	15.79	24.09	1.53
Combined group	93.30	349.08	

By applying the Pearson correlation (P) the utmost usually used in statistics between panorama and CBCT for the calculated doses for all the locations under the current investigation. This P measures the strength and direction of a linear relationship between two variables (means). Values continuously range among -1 (strong negative relationship) as well as +1 (strong positive relationship). Values on or else near zero suggest weak or else no linear relationship. The (P) correlation between different image modalities was done in the current study. The difference was highly statistically significant between the CBCT and Panorama, (P-Value=0.99 and 0.0106 respectively). The correlation coefficient was high besides it took a positive sign. The main contributor to the dose was that from the Oral mucosa and Parotid gland which contributing almost about 90% of the total dose.

DISCUSSION

The utmost main source of public exposure to man-made radiation, are medical exposures. Particularly afterward the integration of the dental implant technique, dental radiology is being extensively used. Hence, the radiographic answers show a significant role in diagnosis and treatment planning. Additionally, the panoramic radiography was used since long time and considered as per the method for much maxillofacial and dental uses. Even if it has a poorer resolution in addition to is more difficult to interpret, panoramic radiography is frequently used as a substitute to intra-oral imaging, may be because the radiation hazard after panorama has usually been considered to be equal to limited intra-oral images [14,15]. On the other hand, CBCT has been commonly used in dental clinics since more than ten years. The radiation dose to the patient is also becoming a main concern, despite the fact that the profits of CBCT have been reported generally [1, 16].

The effective dose, equivalent dose, and absorbed dose are the three basic concepts related to the radiation dose. The absorbed dose is the amount of X-ray energy absorbed by a unit mass (total weight) of tissue, measured in Gray (Gy). The equivalent dose is used to compare the biologic influence of various kinds of radiation on tissue, measured in Sievert (Sv). Intended for a diagnostic X-ray, the equivalent dose is the same to the absorbed dose, then, 1 Gray equivalent 1 Sievert. The effective dose is the probability of biological results afterward radiation exposure. It is used for the assessment of radiation risk. A measurement of the degree of damaging results of single type of radiation on the human body is the effective dose. Its unit is the Sievert, however; micro- or else milli-Sievert are frequently used, in practice [17].

In the present study, the patient absorbed doses measured at different locations in the head and neck area which represent: Upper central tooth, Zygomatic Bone, Oral mucosa, and Parotid gland aiming to estimate the absorbed doses to radiosensitive organs through common dental radiographic investigations. ICRP recommendation about the tissue weighting factors is used to determine the effective radiation doses. It is a significant issue the ICRP version used due to the essential differences in the altered weighting factors. Salivary gland is very much irradiated in dentistry and did not included in The 1990 ICRP [18], but certain authors involved them between the remains tissues of the ICRP, which significantly increased the effective dose. This tissue was integrated in the ICRP as of 2007 [13] in addition 2005[19], then this clarifies the higher doses assessed.

In the current study, there was a difference in absorbed and effective doses of the same organs as expected, due to different exposure parameters used in both devices (Panorama and CBCT). After mouth examination by using Panorama in addition to CBCT Radiograph, the effective dose received are ranged from (3.99 to 67.53 μSv) and (15.58 to 293.14 μSv) respectively depending on the measured locations and the operating parameters (projection techniques).This can be compared with the results of some investigator that found the effective dose after panoramic radiography is 2.7-23 μSv[20-23], Additional studies shows that the i-CAT CBCT brings a greater dose (48-206 μSv) than a classic panoramic radiograph by way of a factor of 5-16. In New Tom (30-78μSv) Galileos (70-128μSv) Mercuray (283-1073 μSv) [24].Most of these values are built on the ICRP 60 (1990) [18] (tissue weighting factors) and range of difference in the effective dose was due to using different sizes "dento-alveolar" and "craniofacial" by different machines in these studies. The difference in the effective dose is influenced by size, shape of the collimation and, speed of the detector, projection technique, beam direction in intra-oral imaging, TLD placement, tissue weighting factors, and differences in film/detector speed [25]. So, while comparing the effective doses reported from different studies, all these factors should be considered and weighed.

The studies focused on the straight comparison of the effective doses received from CBCT as well as conventional dental radiography, are limited. The effective dose for panoramic radiography was found in some studies about 22.0 µSv. It is 61-134 µSv for CBCT examination and about 4.5 µSv for lateral cephalometric examination.There is no study evaluated directly of the effective dose after intraoral besides CBCT examinations. The European Academy of DentoMaxillofacial Radiology guidelines provided that suggested effective dose after single intraoral radiograph is 1.5 µSv [26]. There are additional studies [37-33] which totally assessed the effective dose of conventional dental radiography have established that the range of the effective dose is 3.85-38.0 µSv for a panoramic radiograph.0.659.5-µSv for one intraoral examination, 5.1µSv for posteroanterior cephalometric radiograph and 1.1-5.6 µSv for a lateral cephalometric examination. So, these data display that the effective dose of CBCT is several to hundreds of times greater than that of conventional dental radiographic examination [17]. In the present study, the absorbed radiation skin doses ranged between (130 μGy, 2817.8 μGy) in panorama and (327.99 μGy, 11994 μGy) in CBCT for one exposure. The mean and standard deviation of the absorbed skin dose was found to be higher in parotid gland and oral mucosa respectively using panoramic radiography and CBCT. Comparing the exposure dose by the conventional in addition to the CBCT machines using the mean and Sd, it was found that the mean received in case the panoramic unit (0.182 +/-0.005 mGy) is nearly (2%) of the CBCT used, the minimum and maximum values of the exposure in the CBCT (8.831+/-0.26mGy) is nearly one third (30.7%) of the mean received in case the conventional machine MSCT (26.098 +/-0.5 mGy) [34]. And, the relation of the minimum and maximum values was as well-kept constant [34].

The present study showed that the absorbed dose to the parotid gland, zygomatic bone, oral mucosa and upper central tooth are similar to other studies [13,34] in case of using CBCT and the panorama respectively, based upon publication ICRP -103 (2007) [13,35]. The dose of panorama was considerably lesser than that causing from CBCT. The whole mean exposure in panorama was nearly one fourth that of the CBCT. The high tissue doses obtained in the present study for the parotid gland and Oral mucosa position in both panorama and CBCT reveal the point that at the period of exposure, the salivary glands are situated inside the x-ray beam. Furthermore, in both the anterior and posterior parts of the image layer, the sites of the major glands (submandibular and parotid glands) coincide with the site of the rotational center, additionally, the high tissue weighting factor of oral mucosa. Together with the reviewed evaluations of organ-specific sensitivity, the salivary gland and Oral mucosa doses will have a main influence on the effective dose [14]. Contrary to the results of the present study, another study [16] show that, utmost of the skin absorption dose goes to parotid was (0.23 ± 0.15 mGy) using panorama.

In another study [1, 36] the parotid glands dose was powerfully affected via the selected procedure by CBCT. He also observed the influence of a particular procedure on dose of parotid gland. Parotid gland exposure relied, as for the other organs, on the modality and the protocol used and so it was the only organ systematically positioned inside the primary radiation beam. However**,** it was found that [34], the effective dose to the bone surface was 352 μSv and 7.3 μSv for CBCT and panorama systems. In another study [14], the mean absorbed organ doses of bone surface were 162 µGy in Scanora (dental), 229 µGy in Scanora (jaw) and 69 µGy in Veraviewepocs (dental) from panoramic radiography.

It is difficult to measure the exact radiation dose in the studies. That's because the point of the radiation dose which received from a panoramic radiograph by means of a Well Collimated x - ray beam is movable around the patient then has variability. Thus, the scattered radiation dose is reliant on patient anatomy plus the imaging geometry [16, 37]. The epidemiological studies on a possible association between dental radiography and salivary gland cancer are limited. It was found that full mouth dental examinations were related with a bigger risk on the other hand panoramic radiography was not. Patients who were get to full-mouth intra-oral radiographs in advance 1955[38], at what time exposure settings were noticeably higher, those are who had the greater risk mostly. In addition to the ICRP [13] suggested that among 1 in 100 000 and 1 in 350 000 is the threat of fatal malignancy of the jaws from a CBCT. That is on an adult patient. So, in orthodontics, there are lots of children patients then the danger is greater. The pediatric patient threat is almost twice adult patient threat [37].

The present study as well displays that there is unevenness among CBCT and panoramic units. It is probable that difference in integral machine-specific aspects, other than variations in detector sensitivity, for example focus-detector distance, beam filtration, the path of the effective rotation center, and the central plane of the image layer, contribute to this changeability among units. The lowest level of radiation has to produce the radiographic info. In cases with same consequences, this study displays that total effective dose obtained in panoramic machine lower than the total dose obtained by CBCT taking into consideration that the patient exposure is justified from the IAEA GSR part 3 in 2014[39,40].

CONCLUSION

The results of this study display that the oral mucosa as well as parotid gland get the highest effective doses after both panoramic radiography as well as CBCT. After all sites full mouth examination, the effective dose is lower in case of panorama than CBCT units. It might be concluded that the radiation exposure was higher in the CBCT image in comparison to the panoramic, in addition to the danger have to be weighed compared to the expected advantage of improved image quality obtained by CBCT.

Home message: Finally, clinicians must be conscious of the greater effective dose before utilizing CBCT and panoramic s also had better to choose if this kind of radiography technique is justified to reduce the radiation dangers, besides CBCT have to merely be utilized in case the demand for which imaging is prerequisite cannot be replied sufficiently by Panoramic radiography of the lower dose.

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