Advances in Bioresearch
Adv. Biores., Vol 8 (5) September 2017: 63-67

Print ISSN 0976-4585; Online ISSN 2277-1573
Journal's URL:http://www.soeagra.com/abr.html
CODEN: ABRDC3
DOI: 10.15515/abr.0976-4585.8.5.6367

Advances in Bioresearch

ORIGINAL ARTICLE

Effective Dose Comparison between Digital Radiographs

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ABSTRACT

Digital radiographic systems providing many advantages, such as convenience of storage, elimination of the darkroom equipment and wet procedure, dynamicity,also it is more patient friendly ,less time consuming and results in low radiation exposure. this study sought to assess the effective dose of different digital imaging modalities. The effective dose of panoramic, lateral and posteroanteriorcephalogram derived from Rothograph 2D is 12, 5.6 and 4.4 µSv respectively and lower than full series of intraoral digital radiographs.
***Keywords**: 2D, Digital Radiographs*

Received 16/04/2017 Revised 09/06/2017 Accepted 01/08/2017

How to cite this article:
S Heidarkhan Tehrani, A R Talaeipour, Ladan Hafezi, F Mianji and Naser Valaii. Effective Dose Comparison between Digital Radiographs. Adv. Biores., Vol 8 [5] September 2017: 63-67.

INTRODUCTION

Accurate radiographic images are undeniable part of a proper diagnosis and treatment plan [1]. Today, almost all dental services such as diagnosis and therapy in surgery, orthodontics, periodontics and implants, as well as treatment follow-up is utilizing imaging [2].

Various image modalities is used in different field of dentistry. While panoramics taken for routine evaluation of the entire maxilla and mandible ,teeth, maxillary sinuses and condyles, [3] orthodontics radiographs are usually includes lateral and postero anterior cephalograms [4] as well .Full series of periapical radiographs (FMX) are also known as the gold standard for periodontal assessment [5]. Despite the superiority of 3 dimensional images of Cone beam CT and the inevitable trend of replacement of conventional radiographs with Cone beam CT, [6] two-dimensional radiographs still applied in routine dental practice and they are increasingly common [7]. Digital radiographic systems providing many advantages, such as convenience of storage, elimination of the darkroom equipment and wet procedure, dynamicity,also it is more patient friendly ,less time consuming and results in low radiation exposure [8, 9]. Although digital radiographs results in much lower effective dose than conventional systems,concerns about radiation dose still remains [10]. If enough attention is given to imaging process, proper information can be achieved from little amounts of radiation [11, 8].

Only one study have evaluated the effective dose of all digital imaging techniques [12]. Recently most of the dosimetric studies is based on CBCT scanners [6, 13, 14]. Since two dimensional radiographs are still recommended for establish the primary diagnosis [12] and the importance of radiation dose issue in dentistry, this study sought to assess the effective dose of different digital imaging modalities.

MATERIAL AND METHODS

Units selected for this study were Rotographevo Digital 2D (Villa Sistemi Medicali, Buccinasco, Italy) for digital panoramic, lateral and posteroanterior cephalogramsand Minray (Soredex, Helsinki, Finland)For digital intraoral full series of periapical radiographs(FMX) using photostimulable phosphor (psp)plates with round cone. Table 1 shows the physical parameters for each device/exam.

Table 1:Physical parameters for each device/exam

Exam	Manufacturer	Kvp	mAs	Pixel size	Receptor
PANORAMIC	Villa	68	110.4	96	CCD
LATERAL CEPHALOMETRY	Villa	68	54	96	CCD
P.A CEPHALOMETRY	Villa	68	11	96	CCD
INTRA ORAL	Soredex	70	1.4,2.1	64	PSP
P.A: postero anterior, CCD: charge coupled device, PSP: photo stimulable phosphor					

48 thermoluminescent dosimeterTLD-100H(LiF:Mg , P, Cu) chips(3×1×1mm)were used at 24 selected locations(table 2) in the head and neck of a medium adult tissue–equivalent anthropomorphic RANDO male phantom(Alderson Research lab, Inc Stamford, Connecticut) to record the distribution of the absorbed radiation dose. For calibration, each TLD were exposed to a specific quantity of Cs-137 source radiation and analyzed using an automatic hot gas reader. Individual TLD correction factor was applied for subsequent exposure and reading of each one. Only TLD chips which were calibrated within a 5% error were used in this study. Taking the relatively small amount of radiation into account, ten exposures for each technique were applied.TLDs were read in a Thermo Scientific Harshaw 5500 TLD®reader (Thermo Fisher Scientific, Erlangen, Germany).Then these values were divided by ten to provide single value for each site. Doses for three TLD chips which were not exposed to radiation was subtracted as background radiation of each exam. Doses from TLDs located within the same tissue or organ were averaged to express mean absorbed organ dose.

Table2: Locations of thermoluminescent dosemeter (TLD)chips in radiation analogue dosimetry (RANDO)phantom

Phantom location (Level of TLD location)	TLD ID
Calvarium anterior(2)	1
Calvarium left(2)	2
Calvarium posterior(2)	3
Mid brain(2)	4
Pituitary(3)	5
Right orbit(4)	6
Left orbit(4)	7
Right lens of eye(3)	8
Left lens of eye(3)	9
Right cheek(5)	10
Right parotid(6)	11
Left paritid(6)	12
Right ramus(6)	13
Left ramus(6)	14
Centre C spine(6)	15
Left back of neck(7)	16
Right mandible body(7)	17
Left mandible body(7)	18
Right submandibular gland(7)	19
Left submandibular gland(7)	20
Centre sublingual gland(7)	21
Midline thyroid(9)	22
Thyroid surface-left(9)	23
Oesophagus(9)	24

The products of mean absorbed dose and the percentage of a tissue or organ irradiated in the exams were used to calculate the equivalent dose (HT) in microsieverts (μSv) [16]. For bone marrow summation of the individual equivalent dose to the calvarium, mandible and cervical spine is calculated for the equivalent dose to the whole-body bone marrow [16]. Following the technique of Underhill et al, three locations within the calvarium were averaged to assess calvarial dose [18].
For bone, a correction factor based on experimentally determined mass energy attenuation were used to determine bone: muscle attenuation ratios, two-thirds of the peak beam energy of the X-ray unit used [19].
a bone: muscle attenuation ratio of 4.14 at 45 kV (68 kV peak), 4 at 47 kV (70 kV peak) were used. For skin surface, lymph nodes, connective tissue and muscle, proportional estimation of 5% to the whole body was used to calculate organ absorbed dose within the head and neck area .The proportion of the oesophagous was set at 10% [20].
Effective dose (E) is a recommended calculation for comparing risks from different exposures to ionizing radiation. E, was calculated using the equation:
$E=\Sigma wT\times HT$, where E is the summation of the products of the tissue weighting factor (wT), which represents the relative contribution of that organ or tissue to the overall risk, and the absorbed dose within that tissue(HT) and expressed in μSv [15].

Table 3 shows the dosimeters used to sample each tissue, fraction of tissue irradiated and tissue weighting factors(ICRP2007).

Tissue	TLD ID	Fraction of tissue irradiated (%)	Tissue weighting factor(WT)
Bone marrow		16.5	0.12
Mandible	13,14,17,18	1.3	
Calvaria	1,2,3	11.8	
Cervical spine	15	3.4	
Thyroid	22,23	100	0.04
Oesophagus	24	10	0.04
Skin	8,9,10,16	5	0.01
Bone surface		16.5	0.01
Mandible	13,14,17,18	1.3	
Calvaria	1,2,3	11.8	
Cervical spine	15	3.4	
Salivary glands		100	0.01
Parotid	11,12	100	
Submandibular	19,20	100	
Sublingual	21	100	
Brain	4,5	100	0.01
Remainder			0.12
Lymphatic nodes	11-15,17-22,24	5	
Muscle	11-15,17-22,24	5	
Extrathorasic airway	6,7,11-15,17-22,24	100	
Oral mucosa	11-14,17-21	100	

RESULTS

A summary of effective dose associated with each exam is presented in table 4.The effective dose for posteroanteriorcephalometry exam was 4.4 μSv, which is the lowest, following by lateral cephalometry with 5.6μSv .The highest effective dose results from a full series of intra oral digital radiographs with 66μSv.

Unit/Technique	*Effective Dose (μSv)*	*BM*	*Thyroid*	*Oeso.*	*Skin*	*BS*	*SG*	*Brain*	*LN*	*EA*	*Muscle*	*Oral mucosa*
Panorami	12	12	21	11	4	50	303	10	17	289	17	412
Lat.ceph	5.6	6	52	12	5	25	84	39	4	88	4	94
P.A ceph	4.4	10	24	6	4	40	41	31	3	47	3	52
Intra oral	66	87	120	92	71	346	2133	60	14	265	14	1856

BM- Bone Marrow, Oeso- Oesophagus, BS- Bone Surfaces, LN- Lymphatic nodes, SG-Salivary glands, EA-Extrathoracic airway

DISCUSSION

Effective dose obtained from lateral cephalogram was 5.6μsv.This result is similar with the result of study by Ludlow et al [19]. In their study two different panoramic units were used. Since the mAs of Orthophous XG (Sirona Group, Bensheim, Germany) was 112.1 and closer to our panoramic machine (110.4), the results are same, but for the other unit their result is more than current study due to higher mAs.
For intraoral radiographs the results are different from Ludlow et al [19]. Obtained effective dose of intraoral radiographs was 88 which is about 2 times lower from the study by Ludlow et al [19].[19] This is due to the lower milliamperage used in our study. This issue is critical since effective dose of a full mouth intraoral exam used to estimate about 170 μSv, which is even more than many CBCT scanners.
Another possible reason is different TLD reader and calibration.
Signorelli et al. compared the radiation dose of CBCT and conventional radiographs in orthodontics [2].They reported 5.03 μsv for the effective dose of lateral cephalometry and it is parallel to our result.For P.A cephalometry and panoramic they found much higher values than current study. Presumably the differences between the result of their investigation and our study can be attributed to the usage of analogue system rather than digital imaging technique for cephalogram and of course difference in study set up.
Ludlow et al evaluated the effective dose of two extraoral direct digital imaging devices and found 22 μsv for panoramic view [20] and it is more than our result. Weighting factor used in their study was the older recommendations of ICRP.If the latest ICRP(2007) is being used for calculation of effective dose the difference would be much higher.Grunheid assessed the effective dose of CBCT and orthodontic images and concluded the effective doses for digital panoramic and lateral cephalograms measured 21.5 and 4.5 μSv, respectively [21]. The effective dose for lateral cephalometry is close while for panoramic the difference is due to variation in study set up calibration and physical parameter of the machine.
Lecomber *et al*. used weighting factor recommended by Publication 60 of the International Commission on Radiological Protection (ICRP)including salivary glands, for calculation effective dose and found 9μsv and 3 μsv for panoramic and lateral cephalometry respectively [22]. Gijbels also used the older ICRP recommendation and found 3.4 for effective dose of cephalograms [23]. The difference is owing to disparate weighting factor used to calculate the effective dose. Perhapse include the new 2007 ICRP in these studies for calculation of effective dose results in higher doses. Gavala [24] included the salivary glands into account for weighting factors recommended on 60 ICRP and concluded digital panoramics results lower radiation dose than conventional system although their result is higher than current study. Garcia Silva reported 2.7 μSv for panoramic view [25] and it is much lower than our result. Difference technical parameters, exposure settings, methods of measurement, and calibration of TLD explain the variations of results. In all examinations remainder organs contributed to effective dose more than any other organ, followed by salivary glands and thyroid. Thyroid gland expose to unnecessary radiation in dental imagings. Thyroid collar should be wear during radiographic examinations when it is not interference with the diagnostic or treatment stage. In this study we used a relatively new machine in dental practice. We could not find any dosimetric investigation done on the Rothograph 2D. More studies seems necessary to evaluate the relevancy between, exposure time ,tube current, image quality, and radiation dose of new units. Further researches on novel systems and machines lead to a knowingly decision for purchaser to choose the best equipment for their needs.

CONCLUSION

The effective dose of panoramic, lateral and posteroanteriorcephalogram derived from Rothograph 2D is 12, 5.6 and 4.4 μSv respectively and lower than full series of intraoral digital radiographs.

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