STUDY ON ENTRANCE SKIN DOSE AT PANORAMIC RADIOGRAPHY IN INCHEON, KOREA

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Recently, the use of panoramic radiography has shown a constant increase, and significant research is underway. However, radiation exposure attracts less attention in dental radiography than in other types of radiography. We used an OSLD for measurement of the entrance skin dose in eyeballs and the thyroid region, both of which are not covered by examinations but are included in radiographical regions and are sensitive to radiation, as well as orally in Incheon and reported the results. The entrance skin dose was 0.0282 mSv on average for the oral region, and 0.0259 mSv on average for the eyeball, and 0.0261mSv on average, for thyroid gland. While there is no proper shielding method for the eyeball, a thyroid protector is not used by most hospitals and most hospitals are equipped with an apron and a thyroid protector separately; thus, it is necessary to use an integration of an apron and a thyroid protector and medical device manufacturers need to develop a method for controlling the length of the slit in the slit-type area of radiation occurrence in order to reduce unnecessary exposure.

Keywords : Panoramic radiography, Entrance skin dose, Optical stimulation luminescence dosimeter

1. INTRODUCTION

While no one can deny the fact that medical radiography is very effective and useful in diagnosis and treatment of human diseases, even the radiation dose to which one is exposed in the diagnostic field can never be neglected. Therefore, both the World Health Organization (WHO) and the International Atomic Energy Agency (IAEA) are positively recommending that experts in this field in each country make and use guidelines that meet their conditions in pursuit of the correct use of medical radiography [1].

Although a medical X-ray examination is used for diagnostic purposes, it causes radiation exposure. For this reason, for constant maintenance of radiation devices and relevant equipment is necessary in order to reduce radiation exposure [2].

Recently, the use of dental radiography has shown a constant increase, and significant research is underway. However, radiation exposure attracts less attention in dental radiography than in other types of radiography.

It is necessary to give a systematic explanation of radiation risk with the idea of a quantitative radiation dose rather than the ambiguous explanation that the radiation dose for dental radiography is harmless. In particular, because it causes exposure to a higher dose than oral radiography, panoramic radiography in dentistry requires general analysis of the radiation dose and review of the literature with the objective of investigating actual radiation safety management for panoramic devices. Panoramic radiography in dentistry also gets less recognition and attention from both radiological technologists and society, although it is the task specific to radiological technologists [3].

Shin et al. [1] reported that panoramic radiography is the most frequently used method — 17.8% at university dental hospitals, 24.8% at dental hospitals, and 31.4% at dental clinics — next to oral radiography.

As for other countries, the American Academy of Oral and Maxillofacial Radiology (AAOMR) and others have presented radiation shielding methods, devel-

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opment methods, and criteria for radiation systems for radiography and diagnosis and made systematic management of them [4].

Recently, in South Korea, the Ministry of Welfare and the National Institute of Food and Drug Safety Evaluation presented guidelines for the recommended patient dose in mammography, thoracic radiography, and CT x-ray due to concerns about the hazard of diagnostic radiography [5-8]. However, the recommended dose for panoramic radiography, that forms a great part of dental radiography, with a high radiation dose has not yet been presented. Domestic measurement data on patient dose for panoramic devices are mostly from a single device or each device type, and some researchers used a chamber dosimeter or a semiconductor dosimeter for investigation of the actual panoramic dose, thus showing no accurate dose for each region [9, 10].

Ion chamber dosimeters have different usages for measurement according to the volume of the chamber and selection of a proper chamber is desirable ; however, even a small volume is too large for measurement of the entrance skin dose at a narrow region. While a thermo luminescence dosimeter (TLD) and a glass dosimeter have frequently been used in measurement of the entrance skin dose at each region, an optical stimulation luminescence dosimeter (OSLD) with good dose stability and representation has recently been commercialized for medical use [11] and has frequently been used in measurement of dose on a global basis, and South Korea is increasingly using it by permission for measurement employing a pocket exposure diameter [12].

We used an OSLD for measurement of the entrance skin dose in eyeballs and the thyroid region, neither of which are covered by examinations but are included in radiographical regions and are sensitive to radiation, as well as orally in Incheon and reported the results

2. EQUIPMENT AND METHODS

We used 16 panoramic X-ray devices — seven from university and general hospitals and nine from dental clinics — in Incheon for measurement of the entrance skin dose for panoramic radiography at each region, with the dose pixel located at the central incisor, the right eyeball, and the right thyroid gland, from March to October 2013 (Fig. 1).

We used an OSLD, employed nanoDot, manufactured by LANDAUER, as the dose pixel, and used a MicroStar Reader to read the dose, and used an annealer system (HA-OA001, Hanil Nuclear co.) to provide annealing for 30 minutes before assessing the dose and measured the background value before conduct of the experiment (Fig. 2).

We used Nuclear Associates Model 76-018 as a skull phantom, performed three sessions of radiography under the actual clinical conditions in order to obtain a more accurate dose, and subtracted the background value from the result and divided it by 3 for use as an entrance skin dose for each region.

The Friedman's test was conducted to analyze the difference in radiation dose received according to the three regions (eyeball, central incisor, thyroid gland). In case the result was statistically significant, pair-wise comparisons were conducted as post-hoc analysis. Also, Mann-Whitney U was used analyze the difference between the dental clinic group and dental hospital group. $p < 0.05$ was considered to be statistically significant. Regarding statistical analysis was used SPSS Ver.22.

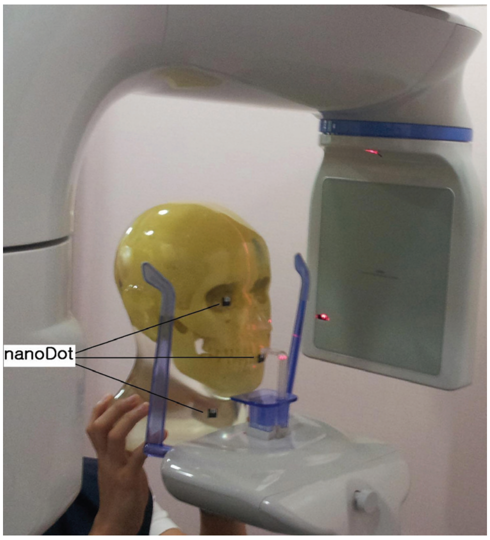

Fig. 1. Measurement of entrance skin dose.

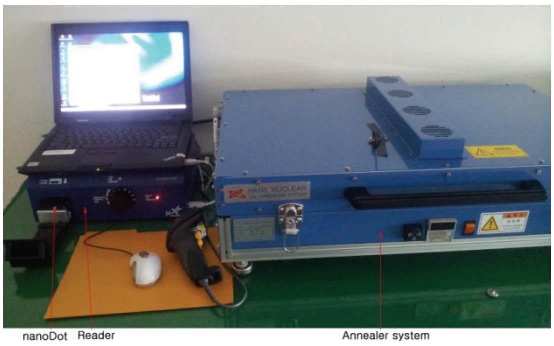

Fig. 2. System of OSLD.

Table 1. Entrance Skin Dose at Panoramic Radiography.

Unit	Exposure factor		Entrance skin dose(mSv)		
	kVp	mA	Eyeball	Central incisor	Thyroid gland
Dental clinic	65	6	0.0071	0.0082	0.0081
	65	8	0.0170	0.0183	0.0174
	67	8	0.0220	0.0235	0.0199
	68	8	0.0165	0.0230	0.0150
	68	8	0.0966	0.1443	0.1031
	68	8	0.0189	0.0202	0.0201
	70	9	0.0356	0.0362	0.0313
	72	10	0.0120	0.0137	0.0191
	73	8	0.0213	0.0195	0.0263
	Sub Mean±SD		0.0275 ±0.027	0.0341 ±0.042	0.0289 ±0.029
Dental hospital	64	8	0.0080	0.0072	0.0051
	66	8	0.0114	0.0207	0.0258
	66	14	0.0087	0.0148	0.0183
	67	8	0.0630	0.0367	0.0543
	67	9	0.0180	0.0185	0.0171
	70	9	0.0445	0.0317	0.0225
	75	8	0.0133	0.0151	0.0146
	Sub Mean±SD		0.0238 ±0.021	0.0207 ±0.010	0.0225 ±0.015
Total Mean±SD	68.19 ±3.082	8.56 ±1.672	0.0259 ±0.024	0.0282 ±0.0321	0.0261 ±0.0233

3. RESULT

The clinical conditions for panoramic radiography included a mean tube voltage of 68.19 kVp, ranging from 64 kVp to 75 kVp, and a mean tube current of 8.56 mA, ranging from 6 mA to 14 mA. Dental hospitals using mean tube voltage of 67.86 kVp using a mean tube current of 9.14 mA and dental clinic using mean tube voltage of 68.44 kVp using a mean tube current of 8.11 mA.

The entrance skin dose for each device was 0.0259 mSv on mean, ranging from 0.0071 mSv to 0.0966 mSv, for the eyeball, showing up to 13.6 times difference as compared with the minimum. It was 0.0282 mSv on mean, ranging from 0.0072 mSv to 0.1443 mSv, showing as great as 20.0 times difference between the maximum and the minimum for the oral region, and 0.0261mSv on mean, ranging from 0.0051 mSv to 0.1031 mSv, showing the greatest difference between the maximum and minimum (20.2 times) for thyroid gland (Table 1).

Table 2. Friedman's Test of Difference in ESD according to Region.

Unit	n	χ^2F	p
Dental clinic	9	6.89*	.03
Dental hospital	7	0.29	.87
Total	16	4.88	.09

*$p < .05$.

Table 3. Pair-wise Comparisons of Dental Clinic.

Pair	χ^2	p
Eyeball - Thyroid gland	-0.44	1.00
Eyeball - Central incisor	-1.22*	.03
Thyroid gland - Central incisor	0.78	.30

*$p < .05$.

Table 4. Test of Difference between Dental Clinic and Dental Hospital Group.

Variable	n	Mann-Whitney U	p
Eyeball	16	25.00	.54
Central incisor	16	27.00	.68
Thyroid gland	16	26.00	.61
Total Mean	16	24.00	.47

The results of the Friedman's test that was carried out to study the difference in the radiation dose in the three regions (eyeball, central incisor, thyroid gland) showed significant difference ($p<0.05$) in the dental clinic group and so the pair-wise comparisons were conducted as post-hoc analysis. The post-hoc analysis showed that the results for the central incisor were significantly higher compared to the eyeball ($p<0.05$). In addition, comparison results of measurement between 9 dental clinics and 7 dental hospitals showed no significant differences (Table 2-3).

4. CONCLUSIVE DISCUSSION

Panoramic radiography uses a narrow vertical beam through a slit-type collimator and has an advantage in that it can show mandibular and maxillary and facial structures in a single consecutive image through only one session of radiography [13]. However, it can cause exposure of eyeballs and thyroid, both of which are not immediately covered by examinations, to radiation. We performed actual measurements of the actual entrance skin dose for each region.

The entrance skin dose was highest in the oral region. Although the thyroid region is not needed for the examination, it was receiving high radiation dose that was statistically not much different from the oral region being radiated. Also, the eyeball had high radiation dose as well although lower than that of the oral region.

This is because the measurement was made at the center for the oral region and at the right side for the eyeball and the thyroid region; greater absorption was observed while x-ray penetrated the phantom through the thickest region of the anterior-posterior position; and an object becomes relatively thinner on a diagonal basis, thus resulting in absorption of a relatively lower dose in the phantom. This trend is similar to that reported by Kim [14], where the right or left position received a higher entrance skin dose than the central one.

In addition, it seems that, in some cases, the eyeball or the thyroid region received a higher dose according to the location of the x-ray tube because the heel effects based on the location of the x-ray tube cause the cathode occur a higher dose than the anode [15]. While there is no proper shielding method for the eyeball, a thyroid protector is not used by most hospitals and most hospitals are equipped with an apron and a thyroid protector separately; thus, it is necessary to use an integration of an apron and a thyroid protector.

The dose around the oral region was approximately three times higher than 0.01 mSv, as reported by Kwon et al. [15], and 2.7 times lower than the result reported by Kim [14]. This can be explained by the result showing that the dose at the oral region ranged from 0.0072 mSv to 0.1443 mSv, showing as great as 20.0 times difference between the maximum and the minimum. It seems that such a significant difference in the dose is due to aging of radiographical devices, different films or digital types, and differences in radiographical conditions, including tube voltage (kVp), tube current (mA), and x-ray occurrence time. In this study, the aging panoramic device also got the highest dose.

On the basis of medical institutional size, the mean dose was approximately 1.65 times higher for clinics (0.0341 mSv) than for hospitals (0.0207 mSv) at the oral region, probably because hospitals have several radiographical devices other than clinics and providing systematic management.

The entrance skin dose for panoramic radiography was assessed at the eyeball, the oral region, and the thyroid region in Incheon and was found to be 0.0282 mSv on average at the oral region. Although this study has a limitation in that it was conducted with 16 devices in one city, domestically, it was the first experiment using an OSLD, which can accurately measure skin dose for each region in panoramic radiography. Shielding of patients is essential due to the high dose at the eyeball and thyroid region, both of which are not immediately covered by radiography, and medical device manufacturers need to develop a method for controlling the length of the slit in the slit-type area of radiation occurrence in order to reduce unnecessary exposure. Since hospitals with relatively better device management administered a lower dose, it is necessary to systematize such device management. Considering that the dose difference reached 20 times or so according to the institutions involved, it seems that the results can be used as basic data in deciding on the recommended dose for panoramic radiography, which increases constantly over a number of sessions.

REFERENCES

1. Shin GS, Kim YH, Lee BR, et al. The actual state and the utilization for dental radiography in Korea. J. of Radiological Science and Technology. 2010; 33(2):109-120.
2. Ogundare FO, Oni OM, Balogun FA. Measurement of x-ray absorbed doses to dental patients in two dental X ray units in Nigeria. Radiat. Prot. Dosim. 2002;102:255-258.
3. Kweon DC, Dong KR, Yung JE, et al. A literature review and analysis of dosimetry in panoramic radiography. J. of Radiological Science and Technology. 2010;33(1):1-10.
4. Quality Assurance Committee of American Academy of dental Radiology, Recommendations for quality assurance in dental radiography, Oral Surg. Oral Med. Oral Pathol., 1983.
5. Ministry for Health, Welfare and Family Affairs. Guide line of diagnostic reference level for mammography. No.16. 2008.
6. Ministry for Health, Welfare and Family Affairs. Guide line of diagnostic reference level for chest

PA. No.17. 2008.
7. Ministry for Health, Welfare and Family Affairs. Guide line of diagnostic reference level for computed tomography. No.19. 2009.
8. Choi SC. Difference in radiation absorbed dose according to the panoramic radiographic machines. Korean J. of Oral and Maxillofacial Radiology. 2000;30(1):11-15.
9. Kim YH, Lee JS, Yoon SJ. et al. Referance dose levels for dental panoramic radiography in Anyang city. Korean J. of Oral and Maxillofacial Radiology. 2009;39(4):199-203.
10. Kang BS, Kim SC, Shin GS. et al. Radiation detection & measurement. Shinkwang Pub. 2012: 164-172.
11. Lee WH, Kim SC, Ahn SM. Comparison on the dosimetry of TLD and OSLD used in nuclear medicine. J. of the Korea Contents Association. 2012;12(12):329-334.
12. Kim HS, Kim HS, Moon HS, et al. Radiographic imaging, Daihaks Pub. 2009:595-598.
13. Kim CG. Measurement dose of dental panoramagraphy using a radiophotoluminescent glass rod detector. Journal of the Korea Academia- Industrial Cooperation Society. 2011;12(6):2624- 2628.
14. Kang SS, Kwon DG, Kim KK, et al. Diagnostic X-ray equipment. 2nd ed. Chung-ku Pub. Co. 2011:71-74.
15. Kwon JW, Jeong JH, Jang KW, et al. Medical exposure of Korean by diagnostic radiology and nuclear medicine examinations. J. of Radiation Protection. 2005;30(4):185-196.