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<원저>

Reduction of Entrance Surface Dose Depending on Shielding Methods for Panoramagraphy

- 파노라마 X선 검사시 차폐방법에 따른 Entrance Surface Dose 저감 -

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— Abstract —

Panoramagraphy was the second most used intraoral radiography utilized in Korea, resulting in 17.8% in university dental hospitals, 24.8% in dental hospitals, and 31.4% in dental clinics. Depending on increased demand like orthodontics and implant, panoromagraphy tends to consistently increase.

This study were used lead glasses and lead shielding to reduce unnecessary radiation to the eyeballs and thyroid. ESD was 41.4% when radiation was shielded with the lead glasses while reducing 47.3% of ESD by shielding the X-ray tube area with shielding lead. There was no statistically significant difference. The lead glasses is appropriated to reduce unnecessary radiation exposure to the eyeballs.

Key Words : Panoramagraphy, Entrance Surface Dose, Eyeball, Lead glasses

Ⅰ. Introduction

Pantomography was first developed in 1949 by Dr. Y. V. Paatero in Finland, and Panorex, the first panoramic radiograph, was introduced to the market in the U.S. The Orthopsntomograph, the first panoramic device, has furnished at Seoul National University in Korea since 1969[1)].

For dental radiography, the important organs of the body such as the brain, eye lenses, and thyroid gland can be easily exposed to even small amounts of radiation. Therefore, radio technologists are required to have the ability to acquire accurate radiography technology, correctly understand the characteristics of radiation, and cope with safety management[2)].

According to the Ministry of Food and Drug Safety (MFDS), the diagnostic reference level[3)] of patient dose for panoramic radiograph is set as 110.9mGy·cm^2 ; however, this reference dose value is based on the Dose Area Product (DAP) meter, so that there is no reference on the areas that are actually exposed to radiation. In addition, according to Choi and his colleagues[4)], radiation exposure to the eye lenses and thyroid gland, which are sensitive to radiation, was found to be very high, although

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these were not necessary when having an actual panoramagraphy. For a general panoramagraphy, the areas of visual interpretation include ramus of mandible and these areas cover from the upper infraorbitomeatal line to the lower hyoid bone[5]. However, with effort, it is possible for radio technologist to prevent unnecessary radiation exposure to the eyeball and thyroid gland. Also, there is no equipment that can control the exposure range of X-ray in panoramagraphy; thus, radiation exposure to the eyeball and thyroid gland can be more dangerous in children with a small head.

According to the Diagnostic X-Ray Equipment Regulation on Safety Management, use of a thyroid shield and lead apron is required when operating a dental panoramic imaging apparatus [6]; however there is no regulation on a protective equipment that can shield against radiation exposure to the areas like eye lenses. Also, the previous researcher found that, there is no hospital equipped with the devices that can protected the eye lenses in Korea[4].

Thus, this study measured the Entrance Surface Dose (ESD) at the thyroid gland, oral region, and eyeballs in a case of wearing lead glasses and thyroid gland protective gear, and a case of implementing a lead shield-used radiation exposure protective apparatus to assess the reduction of radiation dose.

Ⅱ. Equipment and method

The Optically Stimulated Luminescence Dosimeters (OSLDs) were used for measurement of radiation dose. The basic principle of OSLDs is similar to that of the Thermo Luminescence Dosimeter. Once ionized radiation is irradiated to optically stimulated luminescence, electron-hole pairs on the irradiated radiation dose are created and excited electrons that were created through such process are reunited with the hole and some are captured in the energy trap. When light with certain wavelength range is exposed to the captured electron, this captured electron can escape from the energy trap. The possibility of such escape is shown in the formula (1)[7].

$$p = \Phi\xi \quad (1)$$

In this formula, Φ is the intensity of photic stimulation and ξ is the photoionization cross-section.

Meanwhile, $\xi(hv)$ is photoionization cross-section given by[8].

$$\xi(hv) = a\frac{\sqrt{E_i}(hv - E_i)^{3/2}}{hv(hv - \gamma E_i)^2} \quad (2)$$

where a is a scaling constant, Ei is the optical threshold energy for ionization from trap i, and γ is related to the charge carrier effective mass.

The electron that escaped from the energy trap is recaptured in the trap or united and if the electron generates fluorescence at reunion, the amount of fluorescence is measured to determine the radiation dose. Al_2O_3:C (aluminum oxide) is used as the optically stimulated luminous substance. Its effective atomic number is 11.28[9], thus it is very sensitive in dosimeter and since the energy difference between conduction band and valance band is large, with 9.5 eV, the energy trap is stably maintained at room temperature[7].

Due to such characteristics, the Optically Stimulated Luminescence Dosimeters (OSLDs) that enable measurement from low to high dose, nanoDots and Microstar reader (Landauer Co. Ltd., USA) were used in this study. Before conducting the experiment, the background value was measured in advance after annealing for 30 minutes using the annealer system (HA-OA001, Hanil Nuclear Co.) and the values that subtracted the background value from the measured values were used for the dose value.

For the lead glasses, 0.7 mmPb lead equivalent (HF-400S, TORAY) was used whereas 1.0 mmPb lead equivalent was utilized for the thyroid gland protective gear (Fig. 1(a)). For the experiment, a total of 7 nanoDots were used, including the left & right eye lenses and thyroid gland of the Skull Phantom (76-018, Nuclear Associates) and left & right maxillary first premolar. As for the panoramagraphy, Carestream CS-9000 was used and the experimental condition was limited to panoramagraphy to adult men with 70 kV, 10 mA, 14.3 sec. for three times. Then, the average value of three trials was used.

The position of the lead glasses was from the dental root area of the maxillary dentition to infra-orbital groove that did not affect visual interpretation of the maxillary to shield the intended area, and, regarding the lead plate that was used to limit the irradiation range, the lead plate with 1.0 mmPb lead equivalent was used and placed at the front part of the X-ray target area (Fig. 2(a)). After performing panoramagraphy, including the entire mandible and temporomandibular joint, it was verified by a dentist as there was no issue caused for the visual interpretation on panoramagraphy (Fig. 1(b), 2(b)). After the experiment, the ESD of each area in case of shielding and not shielding was compared and the Mann-Whitney U test was performed using SPSS for Windows version 22 to determine statistical significance between the experiment groups.

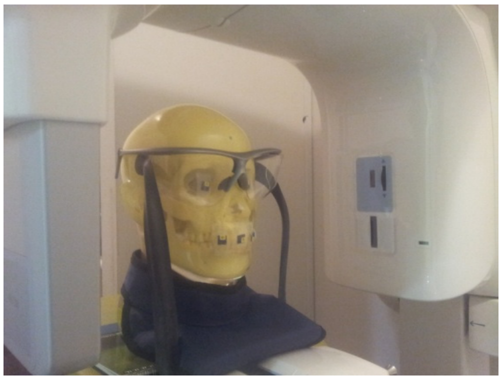

Figure 1(a) Experiment arrangement of the lead glasses & thyroid gland protective gear

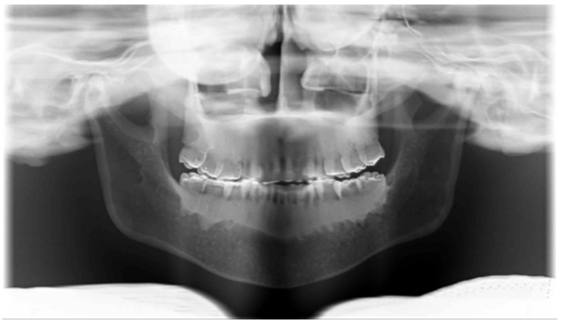

Figure 1(b) X-ray image using the lead glasses & thyroid gland protective gear

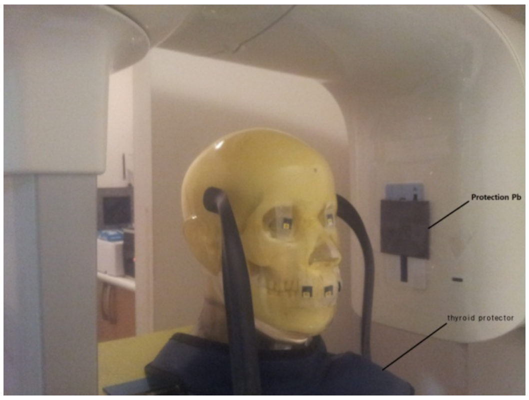

Figure 2(a) Experiment arrangement of the X-ray shielding & thyroid gland protective gear

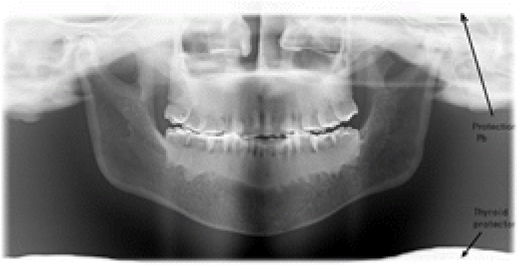

Figure 2(b) X-ray image X-ray shielding & thyroid gland protective gear

Ⅲ. Results

In the case of not shielding, the ESD of the left and right eyeballs were measured to be 72.96 μGy, 54.97 μGy, and 63.96 μGy, on average, whereas that of the oral region was an average of 22.56 μGy. ESD of the thyroid was 20.97 μGy on average. In the case of using the lead glasses and thyroid gland protective gear, the average ESD was 37.45 μGy in the eyeballs, 21.86 μGy for the oral region, and 12.94 μGy for the thyroid. Compared to the case of not shielding the areas, the ESD of the eyeball decreased 58.6% and that of the thyroid decreased 61.7%.

Also, when the shielding lead to limit the exposure range of X-ray was used, the average ESD for the eyeball was 33.73 μGy while it was 23.18 μGy for the oral region and 13.83 μGy for the thyroid. Likewise, ESD of the eyeball was measured to be 52.7% less in the case of no shielding (Table 1). Regarding the statistical significance between shielding and not shielding, no significant difference was found (Table 2, 3).

Ⅳ. Discussion and conclusion

According to Shin and his colleagues[2], panoramagraphy was the second most used intraoral radiography in Korea, resulting in 17.8% in university dental hospitals, 24.8% in dental hospitals, and 31.4% in dental clinics. Depending on increased demand such as orthodontics and implant, use of panoromagraphy tends to consistently increase. In the case of general X-ray machines, the device that limits the exposure range of X-ray is installed; however in the case of panoramagraphy, there is no additional device that limits unnecessary radiation exposure. Therefore, it is considered necessary to implement a controlling that can at least reduce the dose to the eyeballs.

Kim [10] attempted to reduce the dose amount to the eyeballs using lead bending, but, since it was difficult to decide the exact position to be shielded with such lead bending, an issue was raised on the shielding of necessary areas for X-ray. Therefore, this study intended to examine the efficacy of shielding using lead glasses, but, since panoramagraphy generates radiation by rotating X-ray, its shielding effect was not impressive. However, if radiation generated in the X-ray tube is limited, the shielding effect can be maximized as it showed the temporomandibular joint with the infra-orbital groove and the entire mandible [11].

This study shielded to reduce unnecessary radiation to the eyeballs. Although there was no statistically significant difference, the ESD was decreased 41.4%(37.45 μGy) when radiation was shielded with the lead glasses while it decreased 47.3%(33.73 μGy) when shielding the X-ray tube area with shielding lead. Use of the lead glasses to reduce unnecessary radiation exposure to the

Table 1 ESD of each area depending in shielding method

Protection	Region	ESD(μGy)	Ratio(%)
No protection	Eyeball	63.96	100
	Oral region	22.56	-
	Thyroid gland	20.97	100
Lead glass & thyroid protector	Eyeball	37.45	58.6
	Oral region	21.86	-
	Thyroid gland	12.94	61.7
X-ray field device Pb & thyroid protector	Eyeball	33.73	52.7
	Oral region	23.18	-
	Thyroid gland	13.83	65.9

Table 2 Mann-Whitney U test for not shielding and lead glass & thyroid protector

Test statistic(a)	
Mann-Whitney's U	19.000
Z	-.703
Significant probability	.482

Table 3 Mann-Whitney U test for not shielding and Pb that limits unnecessary radiation exposure & thyroid protector

Test statistic(a)	
Mann-Whitney's U	21.000
Z	-.447
Significant probability	.655

eyeballs is appropriate; however, it seems to be more effective for controlling the range of radiation generation at the X-ray tube area because of the characteristic of panoramagraphy that generates radiation by rotating x-ray. In addition, it is necessary for manufacturers to actively utilize devices that can control the extent of radiation exposure around the eyes.

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•국문초록

파노라마 X선 검사시 차폐방법에 따른 Entrance Surface Dose 저감

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한국에서의 파노라마장치의 사용비율은 치과대학병원에서 17.8%, 치과병원에서 24.8%, 치과의원에서 31.4%로 구내촬영장치 다음으로 많이 사용하고 있는 검사 방법으로, 치아교정 및 인플란트 등의 수요증가에 따라 파노라마 검사는 지속적으로 늘어나고 있는 추세이다.

본 연구에서는 파노라마 검사에 불필요한 안구와 갑상선부위의 선량을 감소시키기 위해 납안경 및 납차폐체를 이용해 보았으며, 납안경으로 차폐를 한 경우 안구의 ESD가 41.4% 감소되었으며, X선관 부위 쪽을 차폐납으로 차폐할 경우에는 ESD의 47.3%를 감소시킬 수 있음을 알게 되었다. eyeball의 불필요한 선량저감을 위하여 임상에서는 lead glass를 사용하는 방법이 있으며, 제조사에서는 eyeball부위 피폭을 줄일 수 있는 제어장치를 적극 활용할 필요성이 있는 것으로 나타났다.

중심 단어: 파노라마 X선장치, 표면선량, 안구, 납안경