Analysis of Dose Distribution of Detectors by type of Heel Effect

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Abstract: Background/Objectives: This research originated from the curiosity about what happens to the Does Distribution when shot by the Table Detector and Standing Detector which are used most popularly in general shootings. I compared the difference of Dose Distribution and Heel Effect when irradiated by X- ray in relation to the heel effect, the higher X- ray strength in Cathode than Anode according to the X- ray radiation angle.

Methods/Statistical analysis: This research is shot in condition of SID 100cm, FOV 45 x 45cm, 75kVp, 25mAs (mA:200, Sec:0.125) which is the condition for the head imaging from the Ministry of Food and Drug Safety guideline without phantom. Used the X ray generator TOSHIBA-E7252X as the shooting device, and used CCD Detector CAMCO16M as the Table Detector and Stand Detector. Used Unfors's Xi R/F & MAM detector dosimeter to measure the dose of nine points 3 times each, and computed and compared the average and standard deviation. Also visualized the concentration dispersion by Image J program and compared it. Findings: Table Detector and Standing Detector both showed the tendency to become smaller in dose value in the Anode direction. And both showed the tendency to become smaller in dose value. Overall Dose distribution was more equal in Standing Detector than the Table detector. Improvements/Applications: Through this research, the Standing Detector showed more equal Dose distribution than the Table detector, and the heel effect was bigger in Table detector. So, according to the patient's condition and inspection region, use of proper detector is needed.

Keywords: Table Detector, Standing Detector, Heel Effect, Dose Distribution, general X-ray

I. INTRODUCTION

Since Roentgen discovered X-rays in 1895, various medical devices have been used in the diagnostic field as radiation-based medical care has been introduced[1]. The generation of X-rays means that thermoelectrons emitted by heating the filament in the tube are accelerated by the high voltage applied between the Cathode and Anode poles, collide with the target, and the kinetic energy of the electrons is converted into X-ray and thermal energy[2].

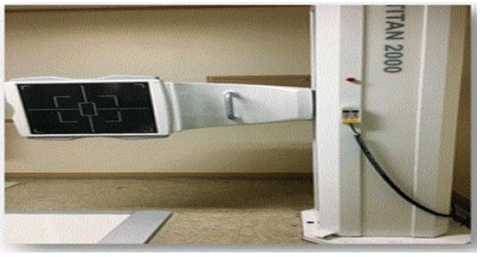
The heel effect is a phenomenon in which the strength of the Cathode side is strengthened by the inclination of the target, and influencing factors include the inclination angle of the Anode side, the presence of the additional filter, FFD, and the field[3-4].When the additional filter is not used, the inclination angle of the Anode is steep, the shorter the FFD, and the wider the field, the effect becomes the more prominent[5-6].

In this study, we tried to compare and evaluate the dose distribution according to the heel effect in Table Detector and Standing Detector under the same conditions.

II. MATERIALS AND METHODS

2.1. Materials

As the X-ray generator and detector used in the experiment, E7252X of TOSHIBA Corporation as well as CCD Detector CAMCO16M was used for both the Standing Detector and the Table Detector as shown in Fig. 1. As shown in Fig. 2, we used Unfors's Xi R/F & MAM Detector as dosimeter, which was calibrated in June 2017.



(a)

(b)

Figure 1.(a) X-ray Generator TOSHIBA-E7252X (b) CCD Detector MC016M

Figure 2.Unfors's Xi R/F & MAM Detector as dosimeter, which was calibrated in June 2017

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Experiments were carried out with FOV 43x43cm, SID 100cm, tube voltage 75kVp, and tube current 25mAs using the head X-ray general photography conditions according to the Guidelines of the Ministry of Food and Drug Safety (MFDS), and the dose measurements and images were evaluated and compared.

2.2. Methods

2.2.1. Dose measurement

As shown in Fig. 3, 9 points were set in the field for dose measurement, the dose was measured three times at each point using a dosimeter, and the mean and standard deviation were derived. And the dose distribution of the Standing Detector and the Table Detector was compared and analyzed.

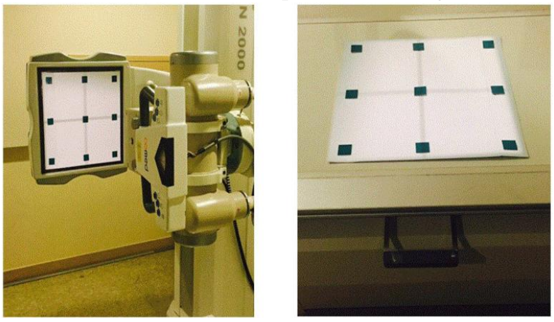

Figure 3. 9points within the exposure area

2.2.2. Image evaluation

From the DICOM file of the image taken by the Table Detector and the Standing Detector, the surface plot profile was obtained by using Image J and the overall concentration and distribution was compared and analyzed.

III. RESULTS

3.1. Dose measurement

First, the mean dose values at the Middle side, which is the most central, were compared. The mean dose values in Table Detector were 167.3mR on the Cathode side, 162.2mR on the Middle side, and 125.3mR on the Anode side, and the dose difference between the Cathode side and the Anode side was 42mR. In the Standing Detector, the mean dose values were 167.5mR, 159.9mR, and 131.4mR respectively, and the dose difference between the Cathode side and the Anode side was 36.1mR. As a result, it was confirmed that the heel effect at the Middle side was larger in Table Detector as shown in Table 1 and Fig. 4.

Table 1. Dose distribution of middle site within detector [mR]

Table detector			Standign detector		
Cathode (-)	Middle	Anode (+)	Cathode (-)	Middle	Anode (+)
167.3(±0.62)	162.2(±1.32)	125.3(±0.47)	167.5(±0.36)	159.9(±0.85)	131.4(±0.42)

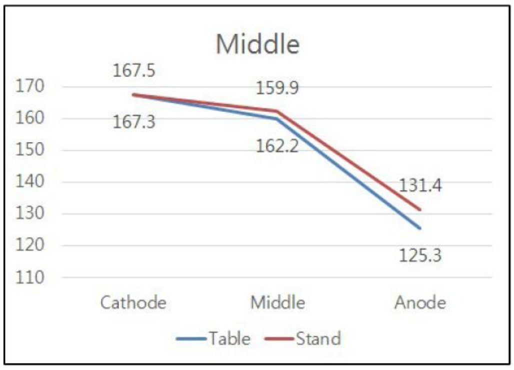

Figure 4. Dose distribution of middle site within detector

Next, we compared the mean dose values of the left side. The mean dose values in the Table Detector were 156.7mR on the Cathode side, 152.4mR on the Middle side, and 119.3mR on the Anode side, and the dose difference between the Cathode side and the Anode side was 37.4mR. In the Standing Detector, the mean dose values were 156.8mR, 150.9mR, and 123.4mR respectively, and the dose difference between the Cathode side and the Anode side was 33.4mR. As a result, it was confirmed that the heel effect in the Table Detector was stronger as shown in Table 2 and Fig. 5.

Table 2. Dose distribution of left site within detector [mR]

Table detector			Standign detector		
Cathode (-)	Middle	Anode (+)	Cathode (-)	Middle	Anode (+)
156.7(±0.53)	152.4(±0.47)	119.3(±0.21)	156.8(±0.60)	150.9(±0.57)	123.4(±0.30)

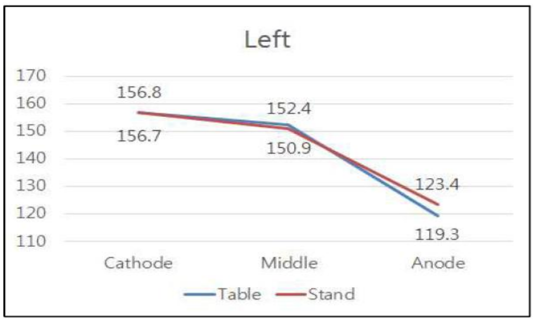

Figure 5.Dose distribution of left sitewithin detector

Lastly, the mean dose values on the right side were compared. The mean dose values in the Table Detector were 170.5mR on the Cathode side, 157.1 mR on the Middle side, and 121.7 mR on the Anode side, and the dose differences between the Cathode side and the Anode side was 48.8 mR, whereas in Standing Detector the mean dose values were 165.4 mR, 156.9 mR, and 119.1 mR respectively, and the dose difference between the Cathode side and the

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Anode side was 46.3 mR.As a result, the heel effect in the Table Detector was larger as shown in Table 3 and Fig. 6.

Table 3.Dose distribution of right site within detector [mR]

Table detector			Standign detector		
Cathode (-)	Middle	Anode (+)	Cathode (-)	Middle	Anode (+)
170.5(±0.53)	157.1(±1.61)	121.7(±0.15)	165.4(±0.93)	156.9(±1.04)	119.1(±0.46)

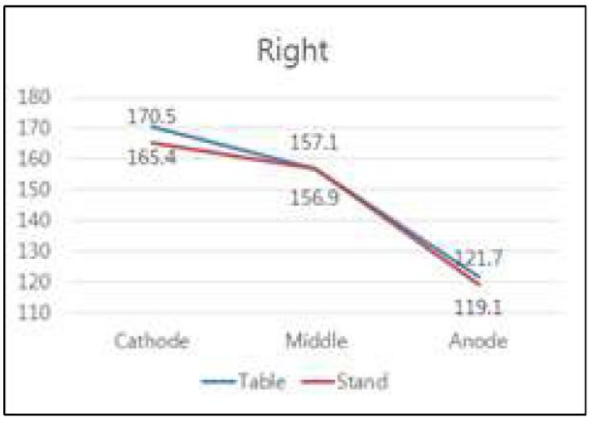

Figure 6.Dose distribution of right site within detector

3.2. Image evaluation

The images obtained from the Standing Detector and the Table Detector were converted to surface plots using Image J and the concentration distribution was checked in three dimensions. The result showed that the density distribution in the Standing Detector was close to a rectangle as shown in Fig. 7 and Fig. 8 and, the heel effect in the Table Detector showed a more pronounced concentration distribution. As a result, it was confirmed that the concentration distribution in the Standing Detector was more uniform.

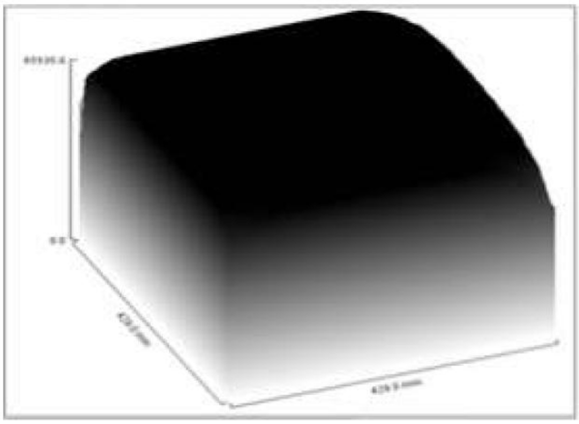

Figure 7.Table detector surface of plot by image J

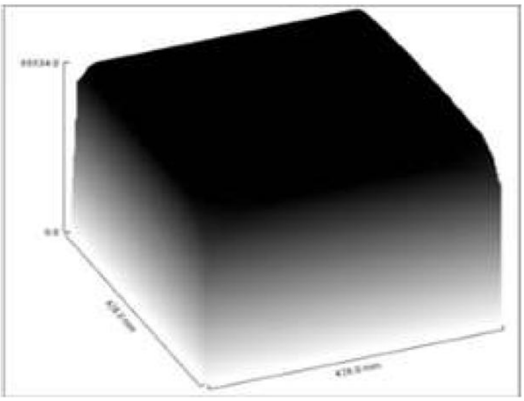

Figure 8. Standingdetector surface of plot by image J

IV. DISCUSSION

According to Kang, Min-ho et al., the dose ratio of the Anode and Cathode decreased but the intensity ratio tended to increase as the field area increased[7-8]. In this study, as a result of dose measurement and comparison of identical points in the field, we found that the dose difference between Anode and Cathode was larger in the Table Detector. Therefore, it is suggested that the photographing using the Standing Detector will have a more uniform dose distribution in the general photographing, and it is recommended that the photographing part and the detector suitable for the dose distribution and the heel effect are selected and taken properly.

In the present study, the difference between the Table Detector and the Standing Detector was considered to be due to the effect of backscattering, but the same pattern as in this study was found in the results obtained by taking the distance of the back space of the detector to be the same[9-11]. Therefore, although it is predicted that there can be an influence on backscattering, but since it is not a direct backscattering measurement, subsequent studies are required. In addition, the experiment is lacking accuracy due to measurement by single equipment and more factors of change regarding backscattering coefficients were not calibrated sufficiently, so it is necessary to carry out accurate experiments taking these factors into consideration in the future

V. CONCLUSION

In this study, we investigated the surface dose distribution of Table Detector and Standing Detector and made a comparison and analysis of the resulting heel effect in order to evaluate its usability, and tried to compare and analyze better images by revealing the difference in concentration distribution using Image J. As a result, both the Table Detector and the Standing Detector showed the dose value increasing toward the cathode side, and when the dose values were compared by each point of the Table Detector and the Standing Detector, the difference in dose value between the Anode side and the Cathode side was bigger in the Table Detector than in the Standing Detector, and the resulting surface dose distribution was more uniform in the Table Detector than in the Standing Detector. In addition, as a result of evaluation and comparison of the 3-dimensional concentration distribution after obtaining

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surface plot of the images using Image J,

the density distribution of the Standing Detector was more uniform and the difference in density distribution by the heel effect was found to be larger in the Table Detector.

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