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A Study on the Image Uniformity According to Center-line Velocity in Digital Radiation System

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Abstract

Background/Objectives: *Generally speaking, it is the case that there is an increase in diagnostic radiators are being examined without aligning the center-line, due to its movement constraint. Therefore, we would like to compare the uniformity of images according to the center-line velocity in the CR System and DR System.*

Methods/Statistical Analysis*: The methods used in this study are to measure the uniformity of the images, as the images were acquired by preparing a 7x7x7(cm) hexagonal phantom with 3mm thick acrylic and adding water. As noted in the CR and DR systems, SID was measured at 150cm and 180cm, and the measurement condition was shown to be 50kVp and 4mAs for each one.*

Findings: *The findings noted that the doses were shown to have a higher cathode value than the center value according to the Heel Effect of the radiation equipment, and were measured lower in the Anode. Although the SNR showed little change in location in the CR System, the difference between the Cathode and Anode in the DR system was more than 8%. In this context, the intensity distribution in this case was shown to show a large variation of the cathode and anode in the CR System with decreasing in the uniformity of the images. Also, it is noted that in the DR system, the uniformity of the image decreased due to a large variation in the anode.*

Improvements/Applications: *In this case, the discordance of the center-line in the DR system was shown to have a large impact on the image and reduced uniformity. Overall in the process of the radiation test, it was analyzed that the degree of uniformity is excellent when the detector and center-line are accorded.*

Keywords*: Digital Radiation System, Central Line, Uniformity, Signal to Noise Ratio, Intensity Distribution.*

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1. INTRODUCTION

Generally speaking, the medical uses of radiation include risks, while it is profitable to use these types of procedures on patients. Therefore, we should apply it into the examination and treatment of patients thr ough optimizing the dose of radiation to improve patient outcomes [1]. In this context, the International C ommission on Radiological Protection (ICRP) Report 26 (1977) recommends radiation to be used "as low as reasonably achievable; ALARA" [2]. For this reason, the examinations essential for diagnosis and treat ment in medical institutions include radiologic examination for diagnosis. As a result, exposure to medical radiation is bound to increase with increased examinations of the patients [3]. Accordingly, the developme nt of the applied study of computers with the increase in the utilization rate of radiologic examination, has brought about many advances and changes in the field of radiologic examination for diagnosis. For this r eason, the introduction of Picture Archiving and Communication System (PACS) is rapidly distributed to l arge and medium hospitals, and it is changing from the existing Film/Screen (F/S) system to the Computer ized Radiography (CR) system and Digital Radiography system(DR) in the general field of radiologic exa mination [4]. In the diagnostic radiation generating system used for examinations of radiology, the film, i maging plate (IP), and the detector describes images with each feature as used in patient care and diagnosi s. However, if the patient's disease is represented differently in the same condition, it will have a significa nt impact on diagnosis and treatment through medical images. Understandably, it is convenient to match th e center-line because F/S system and CR system use Cassette (film) and IP with these procedures. In this analysis, if the center-line is not aligned, the examination is not completed with images that do not match the center-line, which will result due to a decided difference in the image. However, in DR systems, there is an increasing number of examination cases without matching the center-line where the centerline is not aligned because there is no visual difference in the image by correcting during image processing because o f the limits of detector movement or emergency patients [5]. In this study, we would like to analyze the si gnal to noise ratio (SNR) and mean intensity variation (UACI) of images along the center-line in CR and DR systems, which is due to the acquisition method of radiation images currently used in medical instituti ons. It is the case that this analysis requires a study of uniformity and reproducibility of images according to the center-line and its applications.

2. Targets And Methods

2.1. Subject of experiment

The equipment used in this study for measurement are diagnostic radiation generating system (DK-INN OVISION-SH, Japan) and 14×17inch mobile detector (DK-FXRD-1417WB), and 14×17 inch IP Cassette (FCR, Fuji Japan, Type C). In addition, the used water phantom is self-made and made and accompanied b y the use of acrylic as a material. Also, in this case, nine cubes with a thickness of 3mm, height 7cm, wi dth 7cm, length 7cm by 7cm were manufactured for measurement (Fig. 1), (Fig. 2).

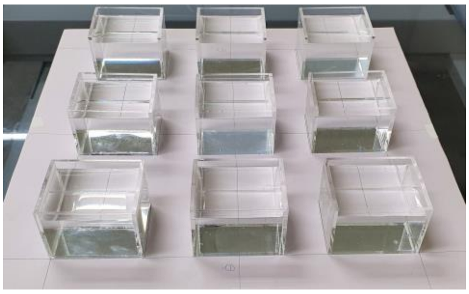

Figure.1 Water Phantom

Figure. 2 Radiation Generator

2.2 Experimental method

2.2.1 Image measurement

In this case, this experiment was conducted on the CR system and DR system. The Source to Image Dist ance (SID) was set to 150 cm and 180 cm, and the center-line was placed sequentially in the center of th e nine water phantom. Here, the left side of the X-ray tube was set to negative and the right side to positi ve. As a result, the measurement condition was set to 50kVp 4mAs.

2.2.2 Dosimetry

In these terms, the dose was measured for each phantom with the X-ray center-line centered on the detec tor. Next, the measurement equipment was used by Radiation Monitor Controller (2026C) and an Electrom eter/Ion-chamber (20X6-60E). At this point, the measurement condition was set at 70kVp, 1mAs (100mA), and the SID was measured at 100cm and 180cm. As a result, the dosimetry for each phantom was execut ed five times to calculate the average.

2.2.3 Image analysis

The SNR was measured to check the uniformity of the images, and the image intensity was measured to measure the intensity distribution of the images according to the center-line changes. In this case, the ima ges used in this study were measured by changing from the DICOM file to Tiff file to minimize the imag e loss.

2.2.3.1 Signal to Noise Ratio

The SNR was measured after placing the center-line in nine water phantom locations and acquiring the i mages. Accordingly, the acquired images of the phantom were measured by setting up to be five places w ith signal and five places without phantom, and the acquired measured values were averaged for SNR acq uisition.

2.2.3.2 signal averaging intensity distribution

The intensity distribution of the peripheral phantom and the image matching the center-line and the cente r of the phantom was measured. Images with a consistent center-line and phantom are based on 1(100%). In this case, it was assessed that if the values of the peripheral images are 1 or close to 1, they are the sa me as those that match the center-line by measuring the change in the negative and the positive values for the peripheral images.

3. Results

3.1. Dose by location according to inspection distance

At a SID distance of 100 cm, the average dose per position of the phantom was shown to be 21. Further more, there was a result of 1mR/min on the negative side, 20.3mR/min in the center, and 15.1mR/min on the positive side. On the basis of center value (100%), the dose on the cathode side was 104% and the do se on the anode side was 74.4% (Table 1). The average dose per position of the phantom at a SID distanc e of 180 cm was shown to be 20.9mR/min on the negative side, 19.9mR/min in the center and 16.9mR/mi n on the positive side. In other words, on the basis of center value (100%), the dose on the negative side was 105% and the dose on the positive side was shown to be 84.9%(Table 1).

Table 1. Dose by location according to inspection distance (Unit : mR/min)

	cathode	center	anode
SID 100 ㎝	21.1	21.3	15.1
SID 180 ㎝	20.9	19.9	16.9

3.2. SNR according to examination distance per system

The center-line was placed in the center of the detector to acquire the image and the value of the center phantom was based on (100%) to indicate the relative difference for the remaining values.

3.2.1 SNR in CR System

In this case, the results of measuring SNR at 150 cm of SID showed that the mean of cathode was 102.5 1%; the mean of the center was 101.21%, and the mean of the anode was 102.01% (Table 2). Therefore, t he results of measuring SNR at 180 cm of SID showed that the mean of cathode was 102.51%, the mean of the center was 101.43%, and the mean of the anode was 101.80% (Table 2).

Table 2. SNR according to inspection distance in CR system (unit : %)

	cathode	center	anode
SID 150㎝	102.51	101.21	102.01
SID 180㎝	102.51	101.43	101.80

3.2.2 SNR in DR system

In this respect, the results of measuring SNR at 150 cm of SID showed that the mean of cathode was 10 4.25%, the mean of the center was 99.66%, and the mean of the anode was 97.81%. Furthermore the resu lts of measuring SNR at 180 cm of SID showed that the mean of cathode was 105.31%, the mean of the center was 99.69%, and the mean of the anode was 95.14% (Table 3).

Table 3. SNR according to inspection distance in DR system (unit : %)

	cathode	center	anode
SID 150㎝	104.25	99.66	97.81
SID 180㎝	105.31	99.69	95.14

3.2.3 Signal averaging intensity distribution according to examination distance per system

In this case, the images with a consistent center-line and the phantom were based on 1(100%) and if the values of the peripheral images were either 1 or close to 1, they were assessed to be the same.

3.2.3.1 Signal averaging intensity distribution of the CR system

3.2.3.1.1 Signal averaging intensity distribution at 150 cm of SID

Through this lens, at 150 cm of SID, the intensity distribution was 0.69 for cathode, 0.39 for center and 0.07 for anode. Therefore, based on the center, the intensity distribution was 0.25 for the cathode, 0.20 fo r the anode and 0.63 for the center. Finally, based on the anode, the intensity distribution was 0.28 for the cathode, 0.56 for the center and 0.76 for the anode (Table 4).

Table 4. Strength distribution at SID 150cm

	Cathode center	Middle center	Anode center
cathode	0.69	0.25	0.28
middle	0.39	0.63	0.56
anode	0.07	0.20	0.76

3.2.3.1.2 Signal averaging intensity distribution at 180cm of SID

Generally speaking, at 180 cm of SID, the intensity distribution was 0.78 for cathode, 0.45 for center an d 0.17 for anode. Thus, based on the center, the intensity distribution was 0.40 for the cathode, 0.32 for t he anode and 0.76 for the center. Hence, based on the anode, the intensity distribution was 0.33 for the ca thode, 0.51 for the center and 0.75 for the anode (Table 5).

Table 5. Strength distribution at SID 180cm

	Cathode center	Middle center	Anode center
cathode	0.78	0.40	0.33
middle	0.45	0.76	0.51
anode	0.17	0.32	0.75

3.2.3.2. Signal averaging intensity distribution of the DR system

3.2.3.2.1 Signal averaging intensity distribution at 150 cm of SID

It is shown that at 150 cm of SID, the intensity distribution was 1.23 for the cathode, 2.49 for the center and 2.13 for the anode. The intensity distribution was shown to be 0.32 for cathode, 1.88 for anode and 1.21 for center. Here, based on the anode, the intensity distribution was 0.08 for the cathode, 0.54 for the center and 1.17 for the anode (Table 6).

Table 6. Strength distribution at SID 150cm

	Cathode center	Middle center	Anode center
cathode	1.23	0.32	0.08
middle	2.49	1.21	0.54
anode	2.13	1.88	1.17

3.2.3.2.1.1 Signal averaging intensity distribution at 180cm of SID

At 180 cm of SID, the intensity distribution was 2.01 for cathode relative to cathode, 4.02 for center an d 4.80 for anode. It is determined that based on the center, the intensity distribution was 0.71, the anode 1 .86, and the anode 2.30. Therefore, the result is that based on the anode, the intensity distribution was 0.9 0, 0.90, and 1.85 (Table 7).

Table 7. Strength distribution at SID 180cm

	Cathode center	Middle center	Anode center
cathode	2.01	0.71	0.90
middle	4.02	1.86	0.90
anode	4.80	2.30	1.85

4. DISCUSSION

In this study, it is noted that the radiographic image examination in modern health care is an important f actor in providing medical services of good quality in the diagnosis and treatment process conducted by m edical institutions. For this reason, medical images play an important role in accurately treating and curing a patient’s illness, since they accurately represent the structure and lesions of the human body [6]. This st udy suggested uniformity of medical images by analyzing the dose, SNR and intensity distribution accordi ng to the center-line, and the changes in the distance of the examination in the CR system and DR system of radiation examination using radiation devices in medical institutions. Here, upon analysis the doses sho wed a cathode value of 4-5% higher than the center value and measured 15-25% lower in anode. In this r egard, it was consistent with the theory that the cathode side is strong, and the intensity distribution is we akly distributed in anode side [7,8]. Upon review, the SNR showed uniform image distribution regardless of Heel Effect in the CR system. However, in the DR system, the overall image was shown to be a lack of uniformity. This result is because it can represent a gradation or dynamic range of digital radiation ima ges [9]. Accordingly, the change in intensity distribution was greater as the distance from the centerline of the CR system. In this way, the change in the intensity distribution of the DR system was small in the c athode and center, with the greatest change in the anode. Although the results from the CR system and D R system were different, the results from the center-line being centered on the detector were consistent wit h small intensity variation. Furthermore, in the digital radiologic examination, this was confirmed to be a good uniformity of images only when the center-line is correctly matched. In this context, it is believed th at good images can be acquired with the image process of the DR system by matching the center-line to t he center of the small detector or IP and conducting the examination.

5. Conclusion

In this study, the images were acquired by analyzing the variation in the intensity distribution of images, according to the SNR and the center-line velocity according to the SID in the CR system and DR system.

In this regard, the doses were shown to be higher in cathode than in center depending on the Heel Effect characteristic of the radiation device, and were measured lower in anode. Evidently, the average value of the SNR in CR System was the highest in the anode with the smallest in the center. For this reason it is noted that the DR system was the highest in the cathode, and the lowest in the anode.

As a result, the variation in the signal averaging intensity distribution was greatest when the center-line v elocity was positive in the CR system, and the difference was insignificant. Upon further analysis in the D R system, the intensity variation was small when the center-line velocity was positive and central.

In conclusion, this study showed that while the change in the CR System was small, the difference betwe en the cathode and the anode in the DR system was significant and considered to be large. Likewise, it w as analyzed that the mismatch of the center-line velocity in the DR system had a large effect on the imag e, and that the center-line velocity should be considered to be consistent in these cases.

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