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Appropriate Inspection Distance of Digital X-Ray Imaging Equipment for Diagnosis

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Abstract

The performance of a diagnostic Digital Radiography (DR) system has been improved. In this study, we determined the appropriate inspection distance that can reduce geometric light sharpness and radiation dose. Phantom images were acquired by creating phantom at size of 14.4 mm × 14.4 mm × 1.5 mm while changing the Object to Image Receptor Distance (OID) and Source to Image Receptor Distance (SID). To acquired phantom images, OID was changed from 5 cm interval to 0 ~ 30 cm and SID was changed from 10 cm interval to 100 ~ 150 cm. The length was measured by Image J program. We used a small focus and experimented this study in tube voltage 40 kVp, tube current capacity 2 mAs. Our results revealed that the enlargement ratio of phantom image was gradually reduced when SID was increased. However, the enlargement ratio was increased when OID was increased. OID distance was the factor that had the most impact on image enlargement in general medical examination using X-ray. It is difficult to control OID in medical image intended for human body. However, SID can be controlled. Therefore, image magnification could be reduced by increasing SID. Reasonable SID was 130 cm in general diagnostic radiology test using a diagnostic DR system.

Keywords: DR (Digital Radiography) System, Image J, Magnification Rate, OID (Object to Image Receptor Distance), SID (Source to Image Receptor Distance)

1. Introduction

Recently, Digital Radiography (DR) system for diagnosis has been developed rapidly with the development of science and technology. In the early 1990s, it was not imagined easily that DR system could be spread out in medical areas such as medical diagnosis. However, from the past 20 years until now, DR is used in many medical institutions. Factors affecting the quality in general radiography (general radiology tests) using the DR system is very diverse, including the process of detecting, obtaining a medical image, X-ray tube that generates X-ray, software processing used to acquire medical image, and the monitor that presents the video. In general radiology tests, it is possible to obtain a black and white digital image according to how much X-ray is attenuated in the process of X-ray transmitted through the subject and how much degree that it is attenuated by the detector. General medical examination by X-ray imaging is accompanied with the expansion of image distortion and resolution degradation inevitably due to geometric unsharpness. Enlarging image, distortion, and degradation of resolution can reduce the value of medical image diagnosis. The situation is caused by the fact that each medical and test equipment does not have the same SID used in the diagnosis of DR equipment.

When we researched about SID used in medical field, it showed differences. SID of 100 cm, 110 cm, 115 cm, 150 cm, etc, have been used. In some cases, the inspection is done without showing the SID used. This situation has the possibility to cause serious distortion from medical imaging equipment. This can alter the magnification and

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resolution of medical images acquired by the Detector. As a result, same subject can be distorted using different SID. Superior medical imaging is to obtain images similar to the actual subject size without geometric distortion. By improving the performance of DR system, the inspection can be done in low irradiation conditions based on the excellent properties of X-ray. As X-ray detection efficiency of the Detector increases, it is possible to obtain an excellent medical image that can reduce the magnification of image by increasing the conventional SID to increased the resolution and sharpness. Therefore, we start conducting this study by using regular medical examinations distance of 100 cm as shown in the textbooks for students majoring in Radiology. However, it needs to be changed to a conventional SID of 100 cm. Based on these problems, the objective of this study was to determine an appropriate SID of general radiology tests using X-ray focusing on reducing image magnification according to SID changes.

2. Research Equipment and Methods

2.1 Research Equipment

2.1.1 Test Equipment

In this study, we used SIMENS's R-800-150/YSIO in indirect conversion method as Diagnosis Digital Radiography (Figure 1). The study condition of maximum voltage of the X-ray tube was 150KV (IEC 60613). The size of the focus (focal spot) was 0.6 mm and 1.0 mm (IEC 60336). For accurate experiment, we conducted primary performance tests as dose reproducibility, tube voltage, tube current test, and half floor test. In all performance test list, we ensured experimental apparatus were within tolerance range.

Figure 1. DR Imaging System.

2.1.2 Phantom

Since the table detector's size of pixel of equipment used in the experiment DR (R-800-150/YSIO) was 0.144mm, we produced a size of height 14.4 mm × horizontal 14.4 mm × vertical 1.5 mm for the copper Phantom to accurately measure the size. To control OID by 5 cm, we used acrylic plate and an acrylic column (Figure 2)..

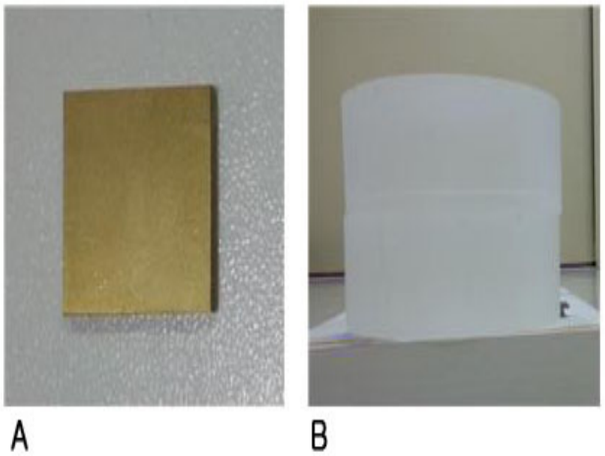

Figure 2. (A) Phantom (14.4 mm × 14.4 mm × 1.5 mm). (B) Acrylic column.

2.2 Methods

2.2.1 Test Method

Using a Produced Phantom to measure the magnification of the image, we measured image zoom of the distance change according to setting of 0 cm, 5 cm, 10 cm, 15 cm, 20 cm, 25 cm, 30 cm for OID in a 5 cm interval. SID was set to 100 cm, 110 cm, 120 cm, 130 cm, 140 cm, 150 cm in a 10 cm interval (Figure 3).

We used Table Detector. Tube voltage was set at 40 kVp and tube current was set at 2 mAs. The shooting condition had a small focus. We did not use Gird or Filter. We stored images as DICOM image file using acquired Phantom. We measured the length using image J.

Figure 3. Phantom measurement of the length.

2.2.2 Image Analysis

Using the phantom, we changed the OID to 0 cm, 5 cm, 10 cm, 15 cm, 20 cm, 25 cm, and 30 cm. With each SID, DICOM image was obtained by measuring 42 times. The acquired image's length was measured by using Image J in order to reduce the length of measurement error. We set the ROI image by extending 800% Phantom. After we measured each value five times, we carried out a quantitative comparison by adopting the measurement of number frequency (Figure 4).

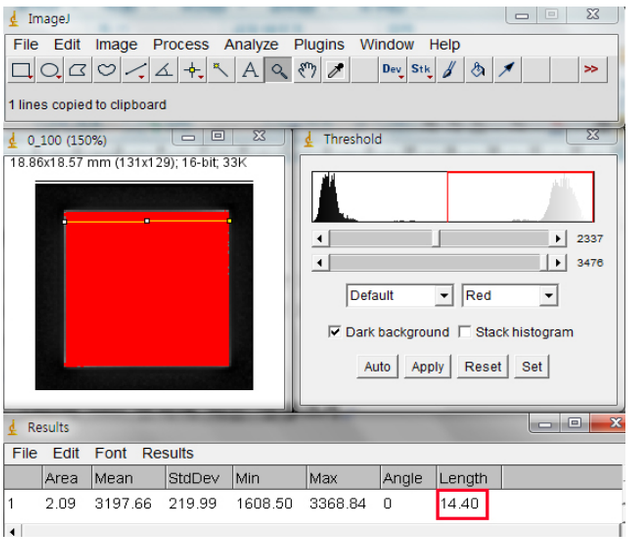

Figure 4. Analysis Program of image 'Image J'.

3. Results

3.1 Analysis About the Length of Image According to SID Change

The higher the OID was, the longer the length of Phantom image was. When OID was at 0 cm, the copper phantom was in close contact with the Detector. The length of the video was constant. It was not extended when SID was increased by 10 cm up to 100 ~ 150 cm.

If the OID was 5cm, the difference in enlarging the length of the Phantom image decreased by 0.15 mm (1.04%) when SID was 120 cm. The magnification was not changed over 120 cm of SID. If the OID was 10 cm, Phantom image length magnification at SID 100 cm was 15.83 (10%). At SID of 130 cm, the Phantom image length was 15.55 (7.99%). At SID of 140 cm, it was 15.41 (7.01%). The phantom image length was gradually decreased when the SID phantom image length was increased.

If the OID was 15 cm, Phantom image length at SID of 100 cm was 16.85 (17.01%). At SID of 110 ~ 120 cm, the Phantom image length was 16.56 (15%). At SID of 110 ~ 120 cm, it was 16.56 (15%). At SID of 130 cm, it was 16.27 (12.99%). At SID of 140 ~ 150 cm, it was 15.98 (10.97%). Phantom image length was gradually decreased when SID was increased.

If the OID was 20cm, Phantom image length at SID of 100 cm was 18.00 (25%). At SID of 110 cm, the Phantom image length was 17.57 (22.01%). At SID of 120 cm, it was 17.28 (20%). At SID of 130 cm, it was 16.99 (17.99%). At SID of 140 cm, it was 16.85 (17.01%). At SID of 150 cm, it was 16.56 (15%). The phantom image length was gradually reduced when the SID phantom image length was increased.

If the OID was 25 cm, Phantom image length at SID of 100 cm was 19.15 (32.99%). At SID of 110 cm, the Phantom image length was 18.58 (29.03%). At SID of 120 cm, it was 8.14 (25.97%). At SID of 130 cm, it was 17.86 (24.03%). At SID of 140 cm, it was 17.57 (22.01%). At SID of 150 cm, it was 17.28 (120%). The Phantom image length was gradually reduced when the SID phantom image length was increased.

If the OID was 30 cm, Phantom image length at SID of 100 cm was 20.45 (42.01%). At SID of 110 cm, the Phantom image length was 19.87 (37.99%). At SID of 120 cm, it was 19.30 (34.03%). At SID of 130 cm, it was 18.72 (30%). At SID of 140 cm, it was 18.29 (27.01%). At SID of 150 cm, it was 18 (25%). Therefore, Phantom image

Table 1. Phantom image length according to the changes in SID S(unit: mm, %)

SID / OID	100cm	110cm	120cm	130cm	140cm	150cm
0cm	14.40	14.40	14.40	14.40	14.40	14.40
M	0	0	0	0	0	0
5cm	14.98	14.98	14.83	14.83	14.83	14.83
M	4.03	4.03	2.99	2.99	2.99	2.99
10cm	15.83	15.70	15.70	15.55	15.41	15.26
M	10.00	9.03	9.03	7.99	7.01	5.97
15cm	16.85	16.56	16.56	16.27	15.98	15.98
M	17.01	15.00	15.00	12.99	10.97	10.97
20cm	18.00	17.57	17.28	16.99	16.85	16.56
M	25.00	22.01	20.00	17.99	17.01	15.00
25cm	19.15	18.58	18.14	17.86	17.57	17.28
M	32.99	29.03	25.97	24.03	22.01	20.00
30cm	20.45	19.87	19.30	18.72	18.29	18.00
M	42.01	37.99	34.03	30.00	27.01	25.00

M: magnification rate

length was gradually reduced when the SID phantom image length was increased (Table 1).

3.2 Analysis About the Length of Image According to OID Change

Phantom image length was decreased as SID was increased by 10 cm (Table 2).

If the SID was 100 cm, Phantom image length was not extended to the same size as the actual size. At OID of 0 cm, Phantom image length was 0%. At OID of 5 cm, Phantom image length was 14.98 (4.03%). At OID of 10 cm, it was 15.83 (10%). At OID of 15 cm, it was 16.85 (17.01%). At OID of 20 cm, it was 18 (25%). At OID of 25 cm, it was 19.15 (32.99%). At OID of 30 cm, it was 20.45 (42.01%). Magnification was increased when OID was increased.

If the SID was 110 cm, Phantom image length at OID of 0 cm was 14.4 (0%). At OID of 5 cm, Phantom image length was 14.98 (4.03%). At OID of 10 cm, it was 15.7 (9.03%). At OID of 15 cm, it was 16.56 (15%). At OID of 20 cm, it was 17.57 (22.01%). At OID of 25 cm, it was 18.58 (29.03%). At OID of 30 cm, it was 19.87 (37.99%). The Phantom image length was increased when OID was increased.

If the SID was 120 cm, Phantom image length at OID of 0 cm was 14.4 (0%). At OID of 5 cm, Phantom image length was 14.83 (2.99%). At OID of 10 cm, it was 15.7 (9.03%). At OID of 15 cm, it was 16.56 (15%). At OID of 20 cm, it was 17.28 (20%). At OID of 25 cm, it was 18.14 (25.97%). At OID of 30 cm, it was 19.3 (34.03%). Phantom image length was appeared to increase with increasing OID.

If the SID was 130 cm, Phantom image length at OID of 0 cm was 14.4 (0%). At OID of 5 cm, Phantom image length was 14.83 (2.99%). At OID of 10 cm, it was 15.55 (7.99%). At OID of 15 cm, it was 16.27 (12.99%). At OID of 20 cm, it was 16.99 (17.99%). At OID of 25 cm, it was 17.86 (24.03%). At OID of 30 cm, it was 18.72 (30%). Phantom image length was appeared to increase with increasing OID.

If the SID was 140 cm, Phantom image length at OID of 0 cm was 14.4 (0%). At OID of 5 cm, Phantom image length was 14.83 (2.99%). At OID of 10 cm, it was 15.41

Table 2. Phantom image length according to the changes in OID (unit: mm, %)

OID / SID	0cm	5cm	10cm	15cm	20cm	25cm	30cm
100cm	14.40	14.98	15.83	16.85	18.00	19.15	20.45
M	0	4.03	10.00	17.01	25.00	32.99	42.01
110cm	14.40	14.98	15.70	16.56	17.57	18.58	19.87
M	0	4.03	9.03	15.00	22.01	29.03	37.99
120cm	14.40	14.83	15.70	16.56	17.28	18.14	19.30
M	0	2.99	9.03	15.00	20.00	25.97	34.03
130cm	14.40	14.83	15.55	16.27	16.99	17.86	18.72
M	0	2.99	7.99	12.99	17.99	24.03	30.00
140cm	14.40	14.83	15.41	15.98	16.85	17.57	18.29
M	0	2.99	7.01	10.97	17.01	22.01	27.01
150cm	14.40	14.83	15.26	15.98	16.56	17.28	18.00
M	0	2.99	5.97	10.97	15.00	20.00	25.00

M: magnification rate

(7.01%). At OID of 15 cm, it was 15.98 (10.97%). At OID of 20 cm, it was 16.85 (17.01%). At OID of 25 cm, it was 17.57 (22.01%). At OID of 30 cm, it was 18.29 (27.01%). Phantom image length was appeared to increase with increasing OID.

If the SID was 150 cm, Phantom image length at OID of 0 cm was 14.4 (0%). At OID of 5 cm, Phantom image length was 14.83 (2.99%). At OID of 10 cm, it was 15.26 (5.97%). At OID of 15 cm, it was 15.98 (10.97%). At OID of 20 cm, it was 16.56 (15%). At OID of 25 cm, it was 17.28 (20%). At OID of 30 cm, it was 18 (25%). Phantom image length was appeared to increase with increasing OID (Table 2).

3.3 Magnification Analysis of the Distance between the SID According the SID and OID Change

When OID changes, the difference of image zoom between the inspection distance could be compared respectively. At OID of 0 cm, image size was not different although SID was increased. At OID of 5 cm, there was no change in the difference of magnification from SID of 130 cm. At OID of 10 cm and SID of 130 cm, the change in magnification was similar between the change in the difference of the magnification reduction. At OID of 15 cm, from SID 130 cm to SID 140 cm, the difference of magnification decreasing was constant. At OID of 20 cm and SID of 120 cm, the difference of magnification reduction was decreased. From SID 120 cm to SID 130 cm, the difference of magnification reduction was constant. At OID of 25 cm, when SID was reduced to 130 cm, the difference of magnification reduction was constant over 130 cm SID. At OID of 30 cm, from SID 110 cm to SID 130 cm, while the difference of magnification reduction was constant, it started to decrease from SID 140 cm SID.

4. Discussion

In general radiology tests, the way to reduce patient dose is by increasing SIT to more than 120 cm and keeping mAs as low as possible to maintain quality. Radiation field adjustment optimized for inspection site using a high kVp will not affect the contrast. Most importantly, it is recommended to keep the optimal dose of test conditions for the inspection site to understand the image quality.

As a study on reduction of patient dose and recommendations, increasing SID will improve the geometric sharpness for quality improvement. The reason to use SID

Table 3. Analysis of Phantom length between SID and magnification rate (unit: mm, %)

SID / OID		100cm	110cm	120cm	130cm	140cm	150cm
0cm	S		0	0	0	0	0
	SM		0	0	0	0	0
5cm	S		0	0.15	0	0	0
	SM		0	1.04	0	0	0
10cm	S		0.14	0	0.15	0.14	0.15
	SM		0.97	0	1.04	0.97	1.04
15cm	S		0.29	0	0.29	0.29	0
	SM		2.01	0	2.01	2.01	0
20cm	S		0.43	0.29	0.29	0.14	0.29
	SM		2.99	2.01	2.01	0.97	2.01
25cm	S		0.57	0.44	0.28	0.29	0.29
	SM		3.96	3.06	1.94	2.01	2.01
30cm	S		0.58	0.57	0.58	0.43	0.29
	SM		4.03	3.96	4.03	2.99	2.01

S: Difference of the length between SID, SM: magnification rate of the length between SID.

of 100 cm is that it is difficult to secure sufficient space in a confined indoor environment. We have great reluctance to change SID because it has been settled and we want to comply the fixed SID that has been used over decades.

In this study, Phantom image size at OID of 0 cm measured the same size of the actual size because phantom was close to the detector in spite of increase of SID by 10 cm. However, when OID was increased, magnification of the image was also increased. The more SID was increased, the more decreased the expansion of video was.

When SID was increased, at OID of 0 cm, there was no difference between image sizes. There were no changes in the magnification in condition of 5 cm OID and SID from 130 cm. When OID was 10 cm, the difference of reduction in the magnification was similar between the changes in magnification from SID 130 cm. In 15 cm OID, from SID 130 cm to SID 140 cm - magnification was decreased. At OID of 20 cm while reducing the magnification to reduce the difference between the calendars was in SID 120 cm to SID 130 cm.

The difference of magnification decrease was reduced in 20 cm OID to 120 cm SID and it was constant from SID 120 cm to SID 130 cm in same OID. In the OID of 25 cm, difference of the decreasing magnification decreased in the course and constant in the end at SID of 130 cm. In the OID of 30 cm - from the SID 110 cm to SID 130 cm, difference of the decreasing magnification was constantly decreased from the SID 140 cm.

We found that the appropriate SID was 130 cm. When SID was at 130 cm, the difference of decreasing magnification was constant according to OID changes. The results of the study by KIM et al.14 was the same. The result that SID should be increased was in consistent with CHOI et al[7].

As a result in the study of image magnification according to the changing SID, We think that the SID 130 cm is a proper inspection distance in diagnosis DR system showing constantly in difference of magnification in each organ. It is in corresponding to a study of WON[5] in terms of Radiation Dose.

We propose an experiment using appropriate SID to enlarge image DR system of equipment limitations of this study. Active research will be needed based on the study and data in a variety of experimental equipment. The objective and reliable picture about the general medical examination of appropriate inspection distance are needed in the future.

5. Conclusion

In general, radiology tests using X-ray tube, the largest influencing factor on the image enlargement, is confirmed to be OID and SID. It is possible to obtain a near-full-scale image of the subject if the subject is thin. It is essential to have a subject as close as possible to the Detector to conduct tests to minimize OID. However, in clinical setting, we might need to obtain excellent medical image by increasing SID to enable the enlargement or reduction of image since it may not be possible to control OID. In conclusion, the proper inspection distance needs to be applied at SID of 130 cm.

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