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Research Paper

Evaluation of image quality according to the use of copper filter in indirect conversion type DR equipment

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Abstract

Background/Objectives: The image quality is evaluated by applying copper to the thickness of filtering filter in indirect conversion type DR equipment. To evaluate the appropriate filter criteria, that does not deteriorate the image quality is obtained for SNR and CNR for each thickness.
Methods/Statistical analysis: Indirect conversion type DR device was used. Acrylic phantom of 12 * 14 size was placed under the same conditions of 85kV, 200mA, 16ms.Experiments were carried out without using a filter, and each of the five copper filters of different thicknesses was irradiated 20 times each. Using the Image j program, an average value and a standard deviation were obtained after designating the region of interest and background area identically. Based on these values, SNR and CNR were obtained and statistical analysis was done by one-way ANOVA. Statistic was used PASW Statistics 18. Release 18.0.0.
Findings: In the non-filter, the SNR value is 26.61 ± 2.05, the CNR value is 0.61 ± 0.06, the SNR value is 30.08 ± 4, 63 and the CNR value is 0.76 ± 0.16 for Cu-filter 0.1mm. In the Cu-filter 0.2 mm, the SNR value is 30.54 ± 4.44, the CNR value is 0.78 ± 0.16, and the SNR value at Cu-filter 0.3mm is 36.91 ± 5.47 CNR value is 1.10 ± 0.22. In the Cu-filter 1.0 mm, the SNR value is 24.88 ± 2.57, the CNR value is 0.71 ± 0.89, the SNR value is 13.82 ± 1.27 and the CNR value is 0.31 ± 0.02 at the Cu-filter 2.0 mm. The highest SNR was 0.3 mm, the highest CNR was 0.3 mm, and the Cu filter 0.3 mm was the highest in both SNR and CNR. There was a significant difference as the result of one-way ANOVA was P = 0.000 and significance level ($p < 0.05$) range.
Improvements/Applications: The use of a filter absorbs much of the low-energy region, The effective energy is increased and the radiation dose is reduced.

Keywords: *Indirect DR; Copper Filter; SN; CNR; Radiation Dose*

1. Introduction

The DR technique is a technique in which images by X-ray energy are collected in a direct pixel matrix form and read out immediately to a monitor. The development of DR has increased the efficiency of image data by enabling the precision of medical image information recording, the flexibility of display, and the transmission of images through other communication networks. [One, 2]
A display technology improved along with the development of the semiconductor industry was the introduction of performance in a digital image detector. This has the physical properties that contribute to the signal without loss of photons with high efficiency of incident x-rays as compared to other methods. Therefore, it is possible to acquire high quality image with low dose. [3, 4]
The DR system is divided into a direct method and an indirect method depending on the X-ray conversion material used for signal detection.The direct conversion method uses a special detector made of a photoconductor, which is a material that converts X-ray photons directly to charges, without using a cassette-type image acquisition device such as a film-screen or a CR. [5]
Indirect conversion method When the X-ray photon is incident on the phosphor or scintillator layer, the detector emits visible light in proportion to this amountThis visible light is recorded by the photodiode and converted into electric charge, and then the X-ray image is stored.This approach has the advantage that the organized scintillation layer reduces the dispersion of light and increases the amount of emitted light and provides high detection quantum efficiency (DQE). [6], [10]
The digital X-ray apparatus has a wider dynamic range than the film / sensitized image and linearity with respect to the dose, thereby reducing the retraining rate and always obtaining a constant image quality by adjusting the grayscale. [7], [9]
However, in digital radiography, the quality of the image is better than that of analog photography, but the radiation dose is so varied that it may be more or less than conventional analog photography.Reduction of x-ray exposure during radiography is not clear

and the noise is increased as the number of x-ray exposure decreases. Radiologists and surgeons prefer relatively overexposure when taking radiographs.12.

Compared with the international reference level (DRL) in the Chest PA test, the diagnostic reference level (CR), 0.51mGy, DR, and 0.62mGy of the FS system, except 0.38mGy, were higher than the reference level of 0.4mGy. Digital systems have been studied to receive more doses in Chest PA examinations13

To reduce the increased dose, international organizations such as the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA) have drawn up recommendations for reducing the exposure dose to patients in the field of radiology. And it recommends to the world suitable for use in a domestic situation.14

Because patients are being exposed to considerable radiation directly upon radiographic International Commission on Radiological Protection (ICRP) in order for Radiation Protection Optimization of the patients according to the ALARA (As Low As Reasonably Achievable) concept while obtaining optimal imaging dose the patient receives To a minimum.[15].

As the use and management of the system become more convenient, efforts should be made to reduce the patient dose of the radiologist. One of them is the use of an additional filter plate which can reduce the dose without deteriorating the image quality. When the additional filter plate is used, the effective energy of the x-ray is increased and the dose of the radiation is relatively decreased because it absorbs a lot of low energy area.To increase the effective energy of X - ray, it was studied that it is effective to reduce dose by inserting metal plates with various kinds and thicknesses of Al, Gd, Mo, Pb, W etc. [16].

It is to filter the X-ray using an additional filter plate. Filtration refers to the act of shaping the x-ray to increase the patient dose, remove the x-rays that degrade the image contrast, and increase the energy rate required for imaging. Diagnostic X-rays are multi-colored radiation consisting of several wavelengths of energy, with an average energy of about one-third of the maximum energy. Most of the low-energy components of multicolor radiation are absorbed within the first few centimeters of the incident radiation to the human body, leading to an increase in patient dose. The x-ray energy emitted from the diagnostic x-ray tube is a continuous spectrum. 17) There are various energy distributions ranging from low energy that can not penetrate the human body to high energy that hinders image contrast. Since the low-energy component does not contribute to the image formation and is absorbed by the subject, the dose of the patient's exposure increases. Therefore, the supplementary plate is effectively used to remove such low energy.In particular, the patient dose depends on the amount of photons absorbed and the first few centimeters of tissue that receives incident x-rays receives much more radiation than other sites. 18The doses received by these tissues can be prevented by inserting an additional filter plate between the X-ray tube and the patient and pre-absorbing low energy components prior to entering the patient.The additional filter plate is made of metal and absorbs low-energy X-rays to reduce patient dose.[8], [11].

That have the greatest impact on image quality and patient dose in the video is called quality of radiation, the quality of radiation is adequate regulation of the use and the tube voltage of because it is affected by the tube voltage and the additional filter plate right additional filter plate will significantly impact the reduced dose will be.

2. Materials and Methods

Chest X-ray examination using high-tension voltage (Chest PA) condition to confirm the image quality according to the thickness of the additional filter plate by technological study of radiologist who is the primary user of X-ray irradiation considering the reduction of exposure dose in medical radiology field. Additional filter plate used in the experiments is to evaluate the quality of the image when a copper material, using 0.1mm, 0.2mm, 0.3mm, 1.0mm, 2.0mm additional filter plate by the thickness of the additional filter plate.

2.1. Experiment

JW medical VIDIX2 indirect conversion type DR device was used. A 12 * 14 size acrylic phantom was placed in the irradiation field of the detector, and a copper filter plate was attached to the entire surface of the collimator. The chest X-ray examination (Chest PA) condition was similar to the condition of 85kV, 200Ma, 16ms.

The experiment was a total of six cases. First, the acrylic phantom was left alone without using the additional filter plate, and 20 times under the same conditions. Second, a Cu-filter 0.1 mm was attached to the front of the collimator and then exposure 20 times under the same conditions. After that, the same procedure was followed for Cu-filter 0.2 mm, Cu-filter 0.3 mm, Cu-filter 1.0 mm and Cu-filter 2.0 mm in this order. Twenty times without using additional filter plates, 20 times with 20 different copper plates with different thicknesses, and total 120 times.

2.2. Analysis

In this study, SNR and CNR index were used for image quality evaluation. The higher the SNR and CNR, the higher the signal and contrast for noise. The DICOM file was obtained and analyzed with the Image J program. After setting both the area of interest and the background area in the image J program, background averages, background standard deviations, ROIaverages and ROIstandard deviations were obtained. The analysis using Image J, background, and ROI are shown in Figure 1.

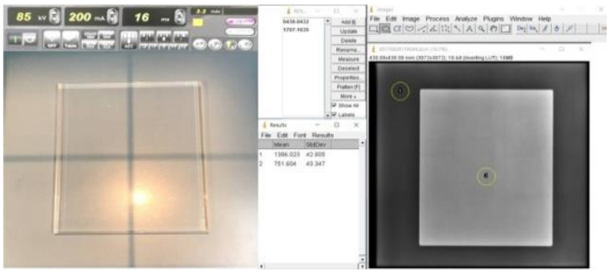

Fig. 1: Phantom & Image J.

Obtaining the SNR is the SNR was calculated by dividing the standard deviation of the entire region of interest, obtain the difference between the average value of areas of interest in the background average value.CNR is a value indicating the degree of contrast of the region of interest with respect to the ambient noise The CNR was calculated by subtracting the mean value of the area of interest from the background average value and then calculating the square of the standard deviation of the background area and the standard deviation of the area of interest

This value was calculated for each of the SNR and CNR using Microsoft Office Excel 2007.The formula for obtaining SNR and CNR is as follows.

$$SNR = \frac{BCGmean - \mathrm{ROImean}}{\mathrm{ROIStdDev}} \quad \ldots\ldots\ldots\ldots \quad (1)$$

$$CNR = \frac{BCGmean - \mathrm{ROImean}}{\sqrt{BCG\mathrm{StdDev}^2 + \mathrm{ROIStdDev}^2}} \quad \ldots\ldots\ldots\ldots \quad (2)$$

Based on the values thus obtained, statistics were obtained by one-way ANOVA. Statistic was used PASW Statistics 18. Release 18.0.0.

3. Results and discussion

The Image J program value of analyzing the respective average values and standard deviations are shown in Table1.

Table 1: The Average Value of Each Filter Results

	BCGmean	BCGStdDev	ROImean	ROIStdDev
Non-filter	3842.59	24.47	2708.46	42.71
Cu-filter 0.1mm	3164.03	36.40	1995.83	39.33
Cu-filter 0.2mm	2991.96	38.44	1826.64	38.56
Cu-filter 0.3mm	2962.00	22.51	1746.62	33.45
Cu-filter 1.0mm	1953.38	36.94	1117.35	33.68
Cu-filter 2.0mm	1365.51	44.16	764.38	43.47

The background average was highest at 3842.59 ± 24.47 when the additional filter was not used and lowest at 13.55 ± 44.16 at the Cu-filter 2.0mm.The average value of ROI was the highest at 2708.46 ± 42.71 when the additional filter was not used, and the lowest at 764.38 ± 43.47 at the Cu-filter 2.0mm.
The analysis of each of the CNR and SNR by one-way ANOVA is shown in Table 2 and Table 3

Table 2: SNR

	N	Mean	StdDev	StdError	P-value
non filter	20	26.61970537	2.053932204	.459273203	0.000
Cu-filter 0.1mm	20	30.08477637	4.632948374	1.035958750	0.000
Cu-filter 0.2mm	20	30.54123056	4.440668560	.992963677	0.000
Cu-filter 0.3mm	20	36.91183861	5.476195209	1.224514475	0.000
Cu-filter 1.0mm	20	24.88291062	2.570563924	.574795567	0.000
Cu-filter 2.0mm	20	13.82701656	1.274425277	.284970155	0.000

Table 3: CNR

	N	Mean	StdDev	StdError	P-value
non filter	20	.61753543	.066840330	.014945952	0.000
Cu-filter 0.1mm	20	.76196286	.164015311	.036674939	0.000
Cu-filter 0.2mm	20	.78483038	.163275883	.036509597	0.000
Cu-filter 0.3mm	20	1.10592957	.226065904	.050549873	0.000
Cu-filter 1.0mm	20	.71800889	.089990563	.020122502	0.000
Cu-filter 2.0mm	20	.31084630	.028860898	.006453493	0.000
Sum	120	.71651891	.273447941	.024962268	

In the non-filter, the SNR value is 26.61 ± 2.05, the CNR value is 0.61 ± 0.06, the SNR value is 30.08 ± 4, 63 and the CNR value is 0.76 ± 0.16 for Cu-filter 0.1mm. In the Cu-filter 0.2 mm, the SNR value is 30.54 ± 4.44, the CNR value is 0.78 ± 0.16, and the SNR value at Cu-filter 0.3mm is 36.91 ± 5.47 CNR value is 1.10 ± 0.22. In the Cu-filter 1.0 mm, the SNR value is 24.88 ± 2.57, the CNR value is 0.71 ± 0.89, the SNR value is 13.82 ± 1.27 and the CNR value is 0.31 ± 0.02 at the Cu-filter 2.0 mm.
The highest SNR was 0.3 mm, the highest CNR was 0.3 mm, and the Cu filter 0.3 mm was the highest in both SNR and CNR. The graphs of these results are shown in Figure 2 and Figure 3.

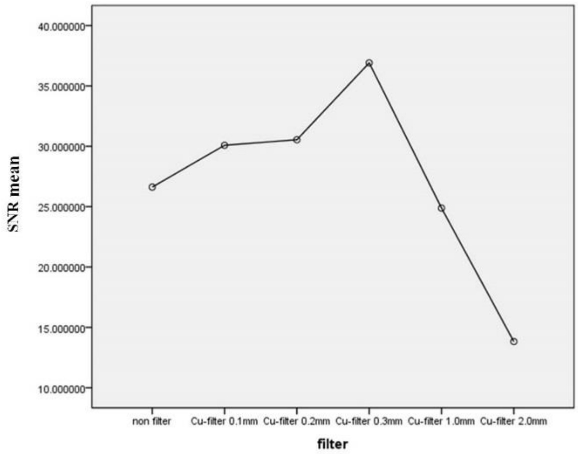

Fig. 2: SNR.

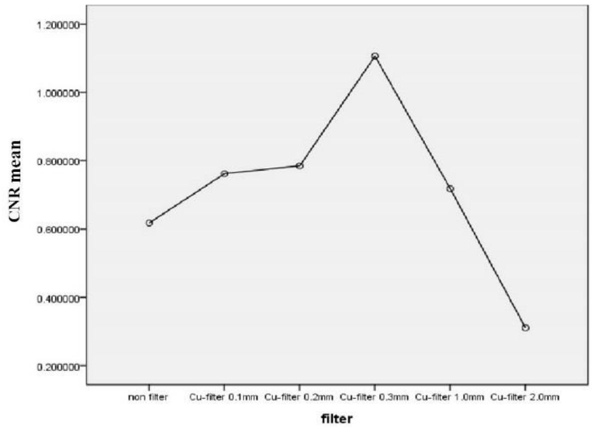

Fig. 3: CNR.

There was a significant difference as the result of one-way ANOVA was P = 0.000 and significance level (p <0.05) range.

4. Conclusion

As people 's quality of life and interest in health are increasing, the number of health screenings is increasing and the number of X - ray examination shots is also increasing. Unlike the past, was limited to patient care is a trend that is increasing and health screenings for early diagnosis of the disease.
In addition, chest x-ray examination is the most frequently performed when patients are regularly followed up at follow-up.Chest radiography is the most common radiographic examination, accounting for approximately 30-60% of all radiological examinations.
However, the chest has a complicated anatomical structure and it is difficult to obtain a good chest X-ray image as the chest diseases vary. Therefore, in order to obtain the best image showing the best information about the patient, the physical characteristics of the X-ray equipment, such as kVp, mAs, exposure time, and filtration, should be thoroughly managed.
Many exposures in diagnostic radiography increase the risk of cancer. Therefore, it is necessary to know doses for X-ray imaging. There is also likely to cause cancer, even if the number of cases taken to the diagnostic area.
Therefore, many methods are being studied to increase the image quality while reducing the radiation dose in the diagnostic field. One way to reduce the exposure dose is to use filtration.
When a diagnostic x-ray passes through a patient, a low-energy photon is absorbed in the first few centimeters of tissue and passes through only the high energy portion to form an image. Since the dose of the patient depends on the number of photons absorbed, the first few centimeters of tissue is more exposed than the other sites.
Filtration is a process that increases the ratio of photons useful for

image formation to a radiation photon that increases patient exposure and lowers the contrast of the image. By inserting a filter material between the patient and the x-ray tube, the radiation dose can be lowered by absorbing low-energy radiation. The filter plate is usually composed of a metal plate, and the function of filtering in radiation is to reduce the patient's exposure dose.

Filtration has inherent filtration and addition filtration. The inherent filtration refers to the filtering action of the X-ray tube and the tube itself until the X-rays are generated in the X-ray tube and come out of the tube. The additional filtration is to artificially insert a metal absorber into the X-ray to absorb low energy photons. The metal of the ideal filter plate should be a metal that absorbs all low-energy photons and passes both high-energy photons. Unfortunately, because such metals do not exist, they prefer metals that are predominantly decaying to low-energy photons. This is mainly due to the fact that when the photoelectric effect is large, the decay is severe and when the compton scatter is large, the decay is reduced.

The additional filter plate does not change the x-ray quality according to the thickness, but the decrease in strength increases the dose required for the same concentration. The use of a suitable filter plate not only increases the average energy but also increases the penetration power, which can be used to reduce the patient dose.

The use of an additional filter plate in the chest X-ray examination of the officials voltage up the dose reduction effect, it is possible to obtain an excellent image. In addition, the use of an additional filter plate absorbs much of the low-energy region, so that the effective energy of the X-ray is relatively increased and the dose of radiation is reduced.

The quality that affects the image quality of the image and the dose of the patient is called the quality of radiation. This quality of radiation is affected by kVp and additional filter plate. Therefore, the use of the right additional filter plate and proper adjustment of the kVp will affect the dose reduction.

SNR is an important factor in DR and image quality is improved in proportion to high SNR. In addition, the quantum noise generated by various variables, phosphors, and electronic components of the DR system at low doses of X-rays reduces the SNR.CNR is a value indicating the degree of contrast of the area of interest with respect to the ambient noise. It is estimated that the higher the CNR, the higher the contrast. When the thickness of the additional filter plate was 0.3 mm, the best SNR and CNR images were obtained.

Chest x-ray is the most basic examination and the most frequently taken examination. It is expected that chest radiography using high kVp will be able to improve the quality of the image and to manufacture equipment with or attached to the additional filter plate of appropriate thickness to reduce the dose of the patient.

In this study, it was not possible to measure the actual absorbed dose with additional filter plate. If the study is done to measure the absorbed dose according to the type and thickness of the additional filter plate, it is expected that it will be possible to obtain the best image while reducing the dose to the patient.

If the filter and the absorbed dose are studied in detail, it will be possible to find an optimized filter depending on the region of the image.

In this study, only the image quality according to the thickness of the copper filter was compared, but other types of filters such as aluminum and nickel were also analyzed to reduce the dose and to obtain a better image by using a composite filter which does not deteriorate the image quality It is expected.

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