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<원저>

An Optimal Structure of a Novel Flat Panel Detector to Reduce Scatter Radiation for Clinical Usage: Performance Evaluation with Various Angle of Incident X-ray

- 산란선 제거를 위한 신개념 간접 평판형 검출기의 임상적용을 위한 최적 구조 : 입사 X선 각도에 따른 성능평가 -

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— Abstract —

In diagnostic radiology, the imaging system has been changed from film/screen to digital system. However, the method for removing scatter radiation such as anti-scatter grid has not kept pace with this change. Therefore, authors have devised the indirect flat panel detector (FPD) system with net-like lead in substrate layer which can remove the scattered radiation. In clinical context, there are many radiographic examinations with angulated incident X-ray. However, our proposed FPD has net-like lead foil so the vertical lead foil to the angulate incident X-ray would have bad effect on its performance. In this study, we identified the effect of vertical/horizontal lead foil component on the novel system's performance and improved the structure of novel system for clinical usage with angulated incident X-ray. Grid exposure factor and image contrast were calculated to investigate various structure of novel system using Monte Carlo simulation software when the incident X-ray was tilted (0°, 15°, and 30° from the detector plane). More photons were needed to obtain same image quality in the novel system with vertical lead foil only then the system with horizontal lead foil only. An optimal structure of novel system having different heights of its vertical and horizontal lead foil component showed improved performance compared with the novel system in a previous study. Therefore, the novel system will be useful in a clinical context with the angulated incident X-ray if the height and direction of lead foil in the substrate layer are optimized as the condition of conventional radiography.

Key Words : Scatter Radiation, Monte Carlo Simulation, Flat Panel Detector, Digital Radiography, Scatter Reduction

Ⅰ. INTRODUCTION

Radiology equipment has contributed to modern medicine for better quality of human life. Especially, as the technology of medical imaging has been improved, diseases can be detected, and medical doctors can diagnose them more accurately [1]. General radiographic examination composes a large

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portion of diagnostic radiology [2]. Therefore, there were many studies on the radiation detector in diagnostic imaging to improve its performance. When the human body is exposed to and penetrated by radiation during radiography, some factors affect image quality such as tube voltage and current, image receptor characteristics, and so on. Among these factors, the most critical element is scatter radiation. Scatter radiation degrades the image contrast [3] thus, many efforts have been made to reduce scatter radiation in the field of diagnostic imaging [4,5].

An anti-scatter grid is commonly employed in radiography to remove scatter radiation [5]. However, there are several shortcomings of the present system [6,7]. Thus, there effort has been made to upgrade the structure of the grid system. As part of these efforts, authors have identified the feasibility of a novel indirect flat panel detector (FPD) system for removing scatter radiation [8]. The novel system has a net-like lead foil in the substrate layer, matching the ineffective area on the thin film transistor (TFT) layer to block scatter radiation so that only primary X-rays can reach the effective area. The novel system showed a lower scatter fraction and higher image contrast than the conventional parallel grid and no-grid systems. Additionally, the usefulness of the proposed system in chest radiography was investigated, and our system showed the possibility of obtaining the same image quality with a lower exposure [9]. The influence of lead foil thickness and effective area was considered in a previous study, but the simulated condition was only conducted with the incident X-ray, which was perpendicular to the plane of detector. However, there are several radiographic examinations requiring an angulated incident X-ray such as Towne's view in skull projection and mobile radiographic imaging [10,11]. In such cases, radiological technologists consider whether using the grid or not according to the angulated incident X-ray [12]. Therefore, the structure of the novel system should be optimized considering clinical conditions for radiography.

This study aimed to identify the performance of a novel system with angulated incident X-ray and to consider an optimal structure for our novel system to obtain more superb performance.

II. MATERIALS AND METHODS

1. Concept of the CsI-based indirect FPD system (reviewed from previous study)

The authors have devised the concept of a novel indirect FPD system for removing scatter radiation. Most types of the current indirect FPD system consist of 3 layers: substrate, scintillation layer, and thin film transistor (TFT) [13]. The TFT layer has a matrix structure consisting of pixels [14]. Each pixel has an ineffective area in part of the edge of pixels such as data and voltage line. Therefore, only the area excluding the ineffective area can detect the signal on the single pixel [15].

The conventional anti-scatter grid system has been located at the top of the detector and will inevitably block the effective area on the pixel by lead foils in the grid. This shortcoming caused not only the increase of exposure but also the occurrence of noise like a moiré pattern on the image. Therefore, we set the lead foil in the substrate layer matching the ineffective area on the TFT layer so only primary X-rays can reach the effective area without any loss by lead foil [Fig. 1].

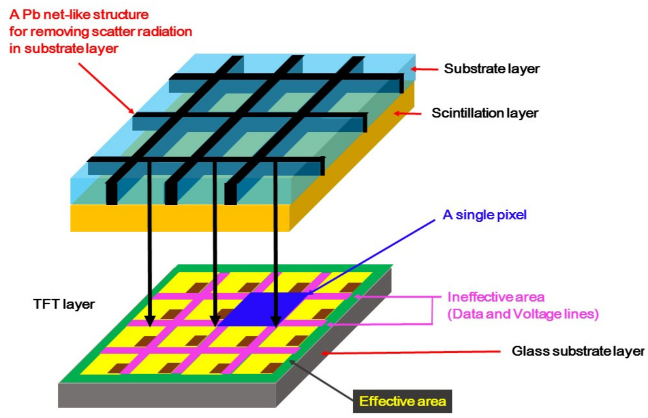


Fig. 1 Concept of proposed detector system to remove scatter radiation

2. Vertical and horizontal alignments of lead to the incident X-ray in the substrate layer

The lead foil in the substrate layer has a net-like pattern because of the placement of ineffective area on the TFT layer. The net-like pattern of lead foil can be separated as the horizontal and vertical component to the angulated incident X-ray. The vertical component of the lead foil, hereafter referred to as the NVC (novel vertical component), interfere with the performance of the proposed system. The NVC will function as the wall to the angulated incident X-rays, so it will block the primary X-rays. On the other hand, the horizontal component of the lead foil, hereafter referred to as the NHC (novel horizontal component), will not interrupt the direction of angulated incident X-ray, so it will be able to maintain the performance of the proposed system [Fig. 2, 3].

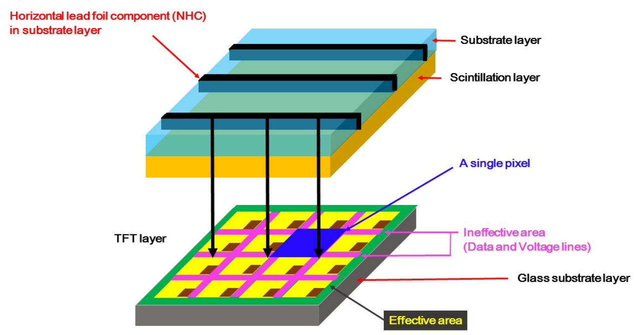


Fig. 2 Illustrated scheme of horizontal lead foil component in the substrate layer of the proposed detector system (Direction of incident X-ray is top left to bottom right in this illustration)

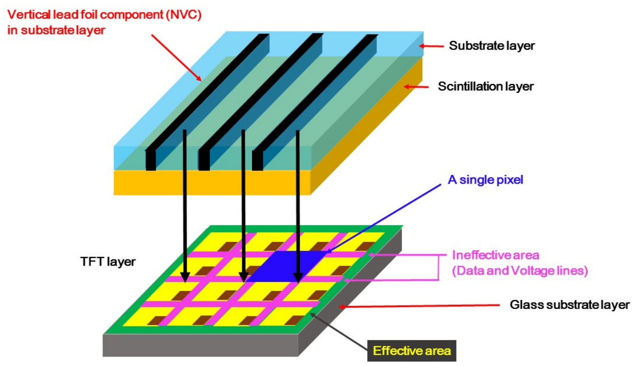


Fig. 3 Illustrated scheme of vertical lead foil component in the substrate layer of the proposed detector system (Direction of incident X-ray is top left to bottom right in this illustration)

3. An optimal structure for a clinical context with the angulated incident X-ray

In clinical contexts, there are many radiographic examinations, and every examination involves a unique radiographic technique. Radiological technologists set up the anti-scatter grid system appropriately according to the type of examination, physique of patient, and angle of incident X-ray [16]. However, since our proposed system cannot remove the lead foil in the substrate layer once it has been manufactured, radiological technologists may not be able to conduct the examination under the best conditions. Especially, in the case of the angulated incident X-ray, if the parallel grid is placed perpendicular to the incident X-ray, a setup error occurs and causes degradation of image quality and increase of exposure. Therefore, we improved our system to show better performance even at the angulated incident X-ray while maintaining excellent performance at the incident X-ray perpendicular to the detector plain, which was investigated in previous studies [8,9].

The height of the vertical and horizontal lead foil components in the substrate layer was set differently in this study. In other words, we set the height of the vertical lead foil component lower and that of the horizontal foil component higher [Fig. 4].

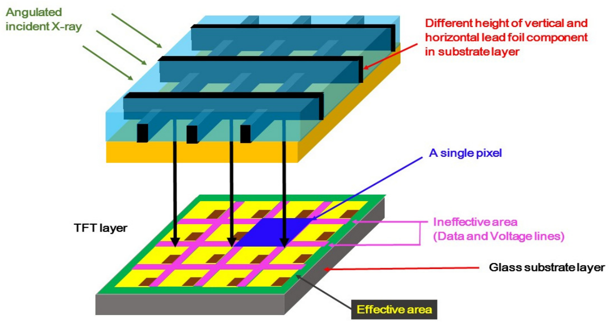


Fig. 4 Illustrated scheme of improved structure of the proposed system having different heights of its vertical and horizontal lead foil components. Height of the horizontal lead foil is greater than that of the vertical lead foil in this structure.

4. Monte Carlo simulation to investigate an effect on horizontal and vertical lead components of the proposed detector system

To identify an effect on the horizontal and vertical lead foil components of the proposed detector system and the performance of an optimal structure of proposed system, we conducted Monte Carlo simulation using MCNPX 2.6.0 software [17] (Los Alamos National Laboratory, Los Alamos, NM, USA). A continuous X-ray spectrum was produced by SRS-78 software [18] with the following conditions: a tungsten (W) anode, a 12° target angle for the anode, and an additional 0.5-mm-thick copper filter Three angles (0°, 15°, and 30° from the plane of detector) were used in this study. [Fig. 5]. The incident X-ray for Towne's projection

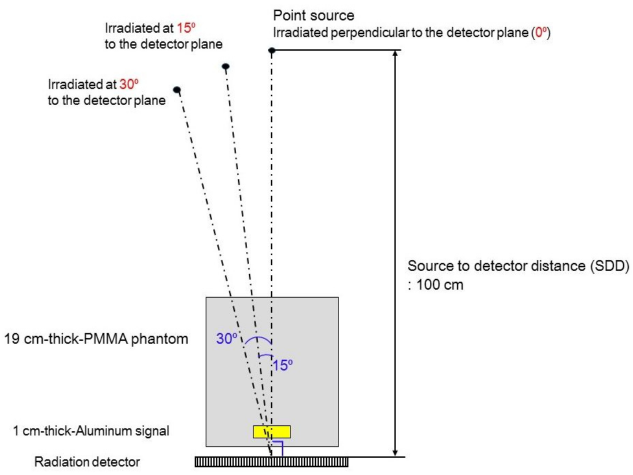


Fig. 5 Illustrated scheme of simulated geometry in this study

travels anterior to posterior (AP) direction, with about 30~40° of angulation from about 5 cm above the level of the nasion, toward the foramen magnum. Therefore, we simulated the maximum angle of incident X-ray to the detector plane as 30°.

Point source radiation was used, and beam width was set to cover all dimensions of the detector (2 cm × 2 cm) in our simulation. The tube voltage was 80 kV, and the 19-cm-thick poly (methyl methacrylate) (PMMA) phantom with 1-cm-thick aluminum signal was used as the object corresponding to the skull radiography [19]. The system with no grid, proposed system in a previous study [8], NHC, NVC, and optimal structure system having different heights of lead foil in the vertical and horizontal direction were simulated. The NHC and NVC system had three kinds of lead foil height: 286, 572, and 858 μm. The optimal structure of the proposed system was a height of 286 μm for the vertical lead foil component and 858 μm for the horizontal lead foil component in the substrate layer. Table 1 shows all specifications of the system simulated in this study. To simulate the indirect FPD, the substrate layer was set as graphite (C-6) with 2.15 g/cm^{3}density. The material of scintillation layer was CsI (density:4.51g/cm^3, thickness: 600 μm) with a Cs-55 to I-53 ratio of 1:1. To identify the result of photon absorption in each pixel, F8 tally (pulse height) was used. In addition, F2 tally was used to count the number of photons entering the plain of the detector. The number of histories was controlled to maintain a statistical error under 5%.

Table 1 Specification of the NHC and NVC system simulated in this study

	Proposed system in previous study [8]	NHC	NVC	Optimal system
Matrix size	129 × 129	129 × 129	129 × 129	129 × 129
Total pixel size [μm^2]	163	163	163	163
Thickness of lead foil (ineffective area)[μm]	20	20	20	20
Effective area of each pixel [μm^2]	143	143	143	143
Height of CsI [μm]	600	600	600	600
Height of lead foil [μm]	572	286, 572, 858	286, 572, 858	286 (Vertical), 858 (Horizontal)

5. Index for evaluating the performance of the proposed system

1) Grid exposure factor

If radiological technologists use the anti-scatter grid, a larger exposure is needed to acquire identical image quality to when the anti-scatter grid is not used. The Bucky factor is the most common index of how much more exposure is needed to obtain the same optical density when the anti-scatter grid is not used in an analog system [20].

Radiological imaging devices have changed from analog to digital systems, such as computed radiography (CR) and digital radiography (DR) [21]. Specifically, the characteristics of the analog system using the film/screen and the digital radiation detector such as direct/indirect FPD use a totally different mechanism to create the image. Therefore, the international electro-technical commission (IEC) has proposed the grid exposure factor as an alternative to the Bucky factor for evaluating the performance of the anti-scatter grid in a digital system. According to the IEC standard 60601-1-3, the grid exposure factor is defined as the inverse of the transmission of the total radiation (T_t) [22]. T_t can be evaluated as the ratio of the total number of photons measured with the object placed in the radiation beam to that measured with the object removed from the beam under specific measurement conditions [22]. All simulations are performed under the same exposure conditions: the total number of incident photons on the detector plane was calculated as the total transmission rate, which was used to decide the grid exposure factor. The grid exposure factor for each system was normalized by the value of the grid exposure factor for the no-grid system [9].

$$\text{Grid exposure factor} = \frac{1}{T_t}$$

where T_t is the number of incident photons on the detector for each system.

2) Image contrast

The image contrast was calculated to investigate the performance of each simulation condition. A phantom made of PMMA and aluminum was simulated to derive the image contrast. The image contrast was calculated using the following formula [23]:

$$Contrast = \frac{|ROI_{Al} - ROI_{PMMA}|}{ROI_{PMMA}}$$

where is the region of interest for aluminum (Al) and the mean value of pulse height in that region, and is the region of interest for PMMA and the mean value of pulse height in its region. However, it is very difficult to determine the ROIs from images with an angulated incident X-ray. Especially, the region of aluminum extended as the angle of incident X-ray increased. Therefore, we set the ROIs of PMMA and aluminum vertically to avoid the effect caused by the movement of signals in the image[Fig. 6].

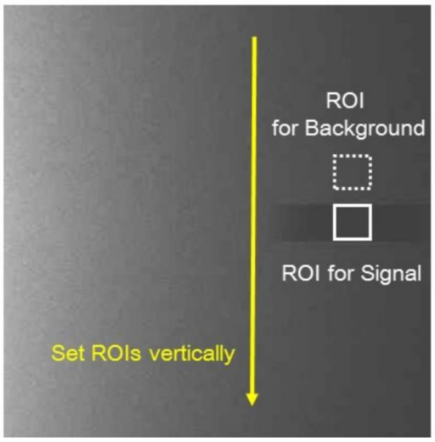
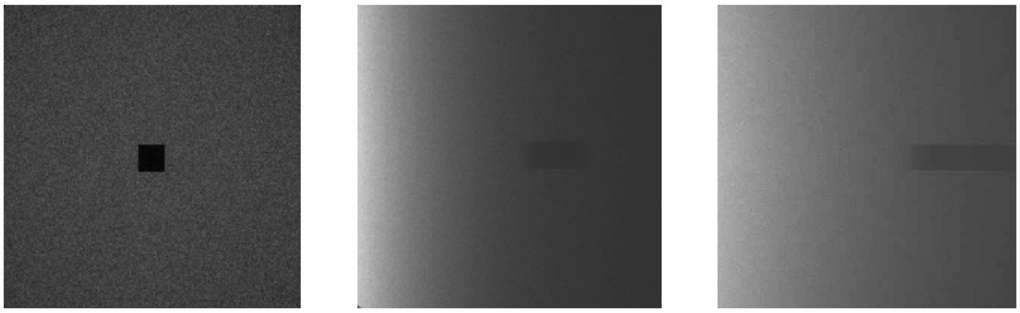


Fig. 6 Schematic illustration of the regions of interest (ROI used to calculate the image contrast) (Direction of incident X-ray is from left to right in this image)

III. RESULTS

Fig. 7 shows the images simulated by the proposed system at each angulated incident X-ray. As the angle of incident X-ray increased, the shadow of signal also extended in the same direction as the



(a) (b) (c)

Fig. 7 Images obtained by the proposed system at every angle of the incident X-ray (a: perpendicular to the detector plane, b: 15° from the detector plane, c: 30° from the detector plane)

Table 2 Grid exposure factor, image contrast, and contrast improvement of all simulated systems with various angles of incident X-ray to the detector plane

	Grid exposure factor			Image contrast			Contrast improvement		
	Angle of incident X-ray to the detector plane								
	0	15	30	0	15	30	0	15	30
No grid	1.00	1.00	1.00	0.43	0.42	0.26	[*]N/A	[*]N/A	[*]N/A
Proposed system in previous study [7]	1.67	2.15	2.31	0.53	0.43	0.27	24%	4%	3%
Optimal system	1.48	1.34	1.35	0.52	0.45	0.28	23%	7%	7%
NHC[**] [286μm]	1.21	1.20	1.21	0.47	0.44	0.28	10%	3%	3%
NVC[***] [286μm]	1.21	1.31	1.40	0.47	0.42	0.26	11%	2%	1%
NHC[**] [572μm]	1.35	1.31	1.32	0.48	0.43	0.27	14%	5%	5%
NVC[***] [572μm]	1.35	1.75	1.88	0.48	0.43	0.27	14%	2%	1%
NHC[**] [858μm]	1.48	1.39	1.40	0.50	0.45	0.28	18%	6%	6%
NVC[***] [858μm]	1.48	2.21	2.44	0.51	0.43	0.27	19%	2%	1%

[*]N/A: Not applicable, [**]NHC: Novel horizontal component, [***]NVC: Novel vertical component

movement of the X-ray tube. The intensity of the X-ray was varied from left to right on the image due to the difference of distance between source and detector.

Table 2 shows the grid exposure factor and image contrast for all simulation conditions at various angles of incident X-ray (0°, 15°, and 30°). In case of the incident X-ray perpendicular to the detector plane (0°), the grid exposure factor of the proposed system was 1.67, and that of the optimal system was 1.48 so that optimal system could acquire identical image quality with 12% less radiation exposure than the proposed system. The NHC and NVC showed the same results in grid exposure factor at the same height of lead. The image contrast of the proposed system was higher than that of the system with no grid. The image contrast of the proposed system was slightly higher than that of the optimal system but indicated almost an identical result. In the case of the NHC and NVC, the image contrast showed almost the same result at the same height of lead.

At the incident X-ray angulated 15° from the detector plane, the proposed and optimal systems must increase the number of photons 2.15 and 1.34 times, respectively, to obtain the same image quality as the no-grid system. Compared with the image contrast of the no-grid system, that of the proposed system was improved about 4%, and that of the optimal system was improved about 7%. Thus, the optimal system can obtain improved image contrast with less exposure. In the case of the NHC and NVC, the grid exposure factor of the NVC was higher than that of the NHC at all heights of lead, and the difference of grid exposure factor between the two conditions grew as the height of the lead foil increased. Additionally, the image contrast of the NHC was more improved than that of the NVC in all heights of lead foil, and the degree of contrast improvement of the NHC grew as the height of the lead foil increased.

Lastly, when the incident X-ray was tilted 30°, the grid exposure factor of the proposed system was 2.31, and that of the optimal system was 1.35. Compared with the image contrast of the no-grid system, that of the proposed system was improved about 7%, and that of the optimal system was improved about 3%. As the height of lead foil increased in the NHC and NVC conditions, the difference of the grid exposure factor between the two conditions grew. The image contrast of the NHC showed a tendency to increase when its height of lead foil was higher, and that of the NVC was improved (1%) in all conditions, indicating no obvious improvement in image contrast.

IV. DISCUSSIONS

In this study, we investigated the performance of our proposed system with a net-like pattern of lead foil through simulations with the incident X-ray angulated and considered the optimal structure of the proposed system for use in clinical examination. First, the grid exposure factor of the NHC and NVC decreased from that of the proposed system at 0° because the lead content of the proposed system was halved in both the NHC and NVC. The lead content and grid ratio have an effect on the reduction rate of scatter radiation and improvement of image contrast [24]. In the NHC and NVC, the lead content was half that of the proposed system; thus, the image contrast also decreased about 5～14% from that of the proposed system. However, as the height of the lead foil increased, the image contrast was improved, because the grid ratio of the NHC and NVC also increased. Therefore, both the proposed and optimal structure systems showed high image contrast with the same number of incident photons on the detector plane.

In the case of the incident X-ray angulated 15° from the detector plane, the proposed system needs 2.15 times more photons than the no-grid system, and, if the incident X-ray was angulated 30°, the proposed system would need 2.31 times more photons to obtain the same image quality. The grid exposure factor of the proposed system with angulated incident X-ray increased over that of the proposed system with perpendicular incident X-ray to the detector plane (0°). Therefore, the proposed system performs well without angulated incident X-ray, but, if the incident X-ray was angulated, it might not work effectively.

The grid factor of the NHC was not changed significantly at all heights of lead in the substrate layer as the angle of the incident X-ray increased (286 μm: 1.21 ± 0.005, 572 μm: 1.33 ± 0.017, and 858 μm: 1.48 ± 0.040). Therefore, the NHC did not affect the grid exposure factor of the proposed system when the incident X-ray was tilted from the detector plane. In addition, the degree of contrast improvement did not vary much as the angle of incident X-ray increased. This result indicated the identical tendency with a previous study [25], which caused very little change in the contrast improvement factor when the incident X-ray was exposed parallel to the direction of grid lines. As the height of lead increased, the grid exposure factor of the NHC also increased, and this result is similar to a previous study [26] finding that the Bucky factor grew and the image quality increased when the grid ratio increased.

The grid exposure factor of the NVC increased at all heights of lead foil in the substrate layer. This NVC structure is similar to the setup error when the conventional grid was placed the wrong way during the general radiographic examination. In addition, when the height of lead increased, the grid exposure factor also increased, but the degree of increase was much bigger than in the NHC. Therefore, the NVC had a bad influence on the performance of the proposed system if the incident X-ray was tilted.

Based on these results, we devised the optimal structure of the proposed system with a lower vertical lead foil component and a higher horizontal lead foil component for the incident X-ray in the substrate layer for use in a clinical context with various angles of incident X-ray[Fig. 4]. The decreased lead content in the vertical component moved to the vertical lead component so that the total lead content of the optimal structure is identical with the proposed system in a previous study [7]. In this optimal structure, the grid exposure factor decreased about 11%, but the image contrast decreased only 2% at 0° of incident X-ray. To acquire the same image quality at 15° of incident X-ray, the existing proposed system needed 2.15 times more photons than the no-grid system, but the optimal structure needed only 1.34 times more photons. The optimal structure showed a similar tendency at 30° of incident X-ray, the grid exposure factor of the proposed system was 1.35, and there were no obvious changes with 15° of incident X-ray but that of optimal structure was 2.31. There were no significant variations with the image contrast between the proposed system and optimal structure at an increasing angle of incident X-ray. Therefore, the optimal structure could create high-quality images with fewer photons at various angles of incident X-ray.

However, as the limitation of this study, if the radiological technologist used our optimal system for horizontal and vertical reverse, this system would not work properly. In addition, there were no clear physical evaluation methods for image contrast with angulated incident X-ray; subjective and visual evaluation with phantom or patent image should be conducted after the development of a hardware system in the future.

Ⅴ. CONCLUSION

The proposed system for removing scatter radiation would be useful in a clinical context with various angles of incident X-ray if the height and direction of lead foil in the substrate layer are optimized as the condition of radiological examination.

REFERENCES

[1] Doi K. Diagnostic imaging over the last 50 years: research and development in medical imaging science and technology. Phys Med Biol 2006;51(13):R5.

[2] Rehani MM. Protection of patients in general radiography. In: Radiological protection of patients in diagnostic and interventional radiology, nuclear medicine and radiotherapy, Proceedings of an International Conference; 2001.

[3] Baek Cheol-Ha. A Study of Scattered Radiation Effect on Digital Radiography Imaging System.. Journal of Radiological Science and Technology 2017;40(1);71-77.

[4] Chan HP, Doi K. Physical characteristics of scattered radiation and the performance of antiscatter grids in diagnostic radiology. Radiographics 1982;2(3):378-406.

[5] Chan HP, Higashida Y. Performance of antiscatter grids in diagnostic radiology: experimental measurements and Monte Carlo simulation studies. Med Phys 1985;12(4):449-454.

[6] Riebel FA. The moir effect in radiography. Am J Roentgenol 1972;115(3):641-643.

[7] Cesar LJ, Schueler BA, Zink FE, Daly TR, Taubel JP, Jorgenson LL. Artifacts found in computed radiography. Br J Radiol 2001;74(878):195-202.

[8] Yoon Y, Morishita J, Park M, Kim H, Kim K, Kim J. Monte Carlo simulation−based feasibility study of novel indirect flat panel detector system for re−moving scatter radiation. Phys Med 2016;32(1):182–187.

[9] Roh YH, Yoon Y, Kim K, Kim J, Morishita J. A novel radiation detector for removing scattered radiation in chest radiography: Monte Carlo simulation−based performance evaluation. J Instrum 2016;11(10):T10008.

[10] Samuel E, Theron C. The radiology of the auditory ossicles. Br J Radiol 1952;25(293):245–252.

[11] Young−Eun Yu1, Cheong−Hwan Lim, Joo−Young Ko. An Analysis of Factors That Affect Image Quality Deterioration in The Potable X−ray Examination on using Digital Wireless Detector. Journal of Radiological Science and Technology 2014;37(2);93–100.

[12] In−Ja Lee, Young− Bok Yeo, Tae−Sung Lee. Entrance Skin Dose and Image Quality Evaluation According to Use Grid Radiography for the Extremity in FPD System. Journal of Radiological Science and Technology 2010;33(4);341–348.

[13] Beutel J Kundel HL, Van Metter RL. Handbook of medical imaging. Volume 1: physics and psychophysics. Bellingham, WA: SPIE Press; 2000.

[14] Rowlands JA, Zhao W, Blevis IM, Waechter DF, Huang Z. Flat−panel digital radiology with amor−phous selenium and active−matrix readout. Radiographics 1997;17(3):753–760.

[15] Chotas HG, Dobbins III JT, Ravin CE. Principles of digital radiography with large−area, electroni−cally readable detectors: a review of the basics. Radiol 1999;210(3):595–599.

[16] Bontrager KL, Lampignano J. Textbook of radio−graphic positioning and related anatomy. Elsevier Health Sciences; 2013.

[17] Pelowitz DB. MCNPX user's manual, version 2.6.0. Los Alamos, NM: Los Alamos National Laboratory; 2008.

[18] The Institute of Physics and Engineering in Medicine report 78. York, UK: IPEM; 1997.

[19] Japan Network for Research and Information on Medical Exposures: J−RIME. Establishment of di−agnostic reference level based on domestic factual survey: 16–19; 2015.

[20] Bonenkamp JG, Boldingh WH. Quality and choice of Potter Bucky grids: I. A new method for the un−ambiguous determination of the quality of a grid. Acta Radiol 1959;(6):479–489.

[21] Busch HP, Lehmann KJ, Drescher P, Georgi M. New chest imaging techniques: a comparison of five ana−logue and digital methods. Eur Radiol 1992;2(4):335–341.

[22] International Electrotechnical Commission, IEC 61267: medical diagnostic X−ray equipment−radiation con−ditions for use in the determination of character−istics; 2005.

[23] Dobbins JT, Samei E, Chotas HG, Warp RJ, Baydush AH, Floyd Jr CE, Ravin CE. Chest radiography: op−timization of x−ray spectrum for cesium iodide−amorphous silicon flat−panel detector 1. Radiol 2003;226(1):221–230.

[24] Bonenkamp J, Boldigh W. Quality and choice of pot−ter Bucky grids. III. The choice of Bucky grid. Acta Radiol 1959;52(1959):241.

[25] Carlin MD, Nishikawa RM, MacMahon H. The effect of x−ray beam alignment on the performance of an−tiscatter grids. Med Phys 1996;23(8):1347–1350.

[26] Tanaka N, Naka K, Saito A, Morishita J, Toyofuku F, Ohki M, Higashida Y. Investigation of optimum anti−scatter grid selection for digital radiography: physical imaging properties and detectability of low−contrast signals. Radiol Phys Technol 2013;6(1):54–60.

•국문초록

산란선 제거를 위한 신개념 간접 평판형 검출기의 임상적용을 위한 최적 구조 : 입사 X선 각도에 따른 성능평가

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진단용 X선 영상에서 산란선은 화질을 열화시키는 주요한 원인이다. X선 장치는 필름/스크린을 사용한 아날로그 시스템부터 Imaging plate (IP) 및 평판 검출기(Flat panel detector; FPD)를 사용한 디지털 시스템으로 바뀌어 가고 있다. 그러나 산란 X선 제거를 위한 Grid는 아날로그 시대에 사용됐던 구조부터 큰 변화가 없다. 본 논문에서는 선행연구에서 고안된 산란선 제거율을 향상시키기 위한 간접변환형 평판검출기의 새로운 구조를 다양한 입사 X선을 사용하는 임상현장에서의 활용 가능성을 검토했다. 일반적으로 FPD는 3개의 층으로 구성되어 있다. 신호를 검출하는 화소와 화소 사이에는 전압을 거는 voltage line이나 데이터를 전달하는 data line과 같은 X선 불감영역이 존재한다. 선행연구에서는 이 불감영역에 정확히 맞추어 방사선 불 투과성의 납을 그물 모양으로 substrate layer에 삽입함으로서 검출기 자체가 산란선 제거 효과가 있도록 설계하였다. 새로운 구조의 임상 유용성을 평가하기 위해, 삽입된 그물 모양의 납을 입사 X선에 대해 가로, 세로성분으로 나누어 각각의 성능을 확인하였으며, 동시에 납의 높이를 변화시켜 납 높이가 성능에 미치는 영향을 영상 대조도와 grid 노출 인자를 통해 검토했다. 검출기면에 대해 대각선으로 입사한 X선(0°, 15°, 30°)에 대해서, 입사 X선에 대해 평행한 가로성분이 세로 성분에 비해 높은 영상 대조도와 낮은 그리드 노출 인자를 나타냈으며, 세로성분의 납 높이가 높을수록 본 연구에서 고안한 검출기에 악영향을 미치는 것을 확인했다. 그러므로 본 연구에서 고안한 새로운 FPD 시스템은 FPD의 구조를 방사선검사 조건과 목적에 맞추어 최적화함으로써 임상 의료현장에서의 사용 가능성이 확인되었다.

중심 단어: 산란선, 몬테카를로 시뮬레이션, 평판형 검출기, 디지털 방사선영상, 산란선 제거