An Evaluation of Optimal Exposure Indicator for Skull X-ray Imaging using Computed Radiography System

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Abstract

The purpose of this study is to evaluate the appropriate exposure indicator in computed radiography for the skull x-rays images. A skull phantom was used during the data collection. The amount of radiation in the air was measured to calculate the entrance surface dose. There was an observation of x-rays images evaluation for images that have the exposure indicator higher than 200. The computer program (efilm version 2.1.2) was used to measure the standard deviation, which indicates the noise in the images. The result concluded that skull AP position x-rays images which have exposure indication value in the range of 200 to 333 are similar in the term of image quality. The skull lateral position x-rays images which have exposure indication value in the range of 200 to 340 also offer similar image quality. To summarize, the images with higher exposure indicators reduce radiation patient dose.

Keywords**:** *Computed radiography, Exposure indicator, Entrance surface dose, Phantom, X-ray position, Radiation dose*

1. Introduction

Digital Computed Radiography (CR) is widely used in hospitals. With the main benefits of digital x-ray imaging that can improve the quality of the original image data. However, the problem of imaging with good quality digital x-ray images depends on the radiation dose. By using high dose radiation to make the image data more clearly but as a result, were found the signal to noise ratio (SNR) as well. (Seibert, Shelton, & Moore, 1995; Workman & Cowen, 1993)

The CR for x-ray imaging can set up a wild range of x-rays more than the using screen-film system. The low dose of radiation affected in poor quality images and causing to repeated x-ray. As a result, we need to reduce repeated radiography from low dose x-ray by using higher radiation dose. This phenomenon is known as “Exposure factor creep” (Warren-Forward et al., 2007; Willis & Slovis, 2005). The CR manufacturer has set the exposure indicator (Fuji) called sensitivity to is an indicator for evaluation of radiation dose in radiography. The problems caused by inappropriate radiation dose in patients to get good quality image data and can be easily adjusted were affect in patients, who were receiving more radiation dose than necessary.

This research uses Fuji's digital x-ray imaging system in the skull radiography from the Fuji Instruction Manual the recommended appropriate sensitivity for radiography between 100 and 400 (Suitable for Skull X-ray Imaging). The research process in the phantom by use X-ray skull phantom with a soft tissue, which is different from other researches because this research uses a skull phantom that is similar to the human's body. The radiation to the skull must be significant because the organ it contains an eye lens that is sensitive to radiation, and excessive radiation may affect the development of cataracts (Protection, 2007) and low doses of radiation can cause permanent damage to the lens, leading to vision loss and cataracts. Higher doses can damage the iris, conjunctiva, sclera, and the retina's blood vessels (Nguyen et al., 2019)

2. Objectives

This research aims to evaluate of optimal exposure indicator for skull x-ray imaging by using a computed radiography system.

3. Materials and Methods

This research was conducted by digital radiography (Quantum Quest HF series) and CR image receiver (Fuji FCR 5000 model). X-rays position of the skull model in anteroposterior (AP) and lateral position, as shown in Figure 1, which is a position commonly used in x-ray imaging.

3.1 Exposure technique

The initial experiment was set exposure technique same as that used for x-ray imaging in patients and then to adjustments exposure technique of radiation with the exposure indicator equals 200. After that, it was increased and decreased exposure technique. So that the data has exposure indicator values in the range from 50 to 800. The exposure technical parameters of skull AP and lateral position were shown in Table 1 and 2. After that, the experiment was repeated to measure the exposure by used ion chamber (RMI 242) and then the exposure dose was used to calculate the entrance surface dose. The entrance surface dose (ESD) is the measure of the radiation dose that is absorbed (mGy) by the skin as it reaches the patient. Entrance skin dose is often a benchmark measurement used to assist in quality control and optimization in radiography departments (Basheerudeen et al., 2017).

Figure 1 Skull model phantom

3.2 Image analysis

Radiographic image with an exposure indicator of 200 or more was selected and displayed on a high-resolution monitor and assessed by a radiologic technologist with at least three years of work experience. The radiologic technologist who assesses the image did not know the technical value for radiography.

The radiographic image was screened by the radiologic technologist and then were analyzed noise in the imaging by defining the region of interest (ROI) in the complex image area of bone and area with many details. In the radiographic image, the skull AP position defines the region of interest in the facial bone, and the lateral position defines in the facial bone area, as shown in Figure 2.

The measured values are the standard deviation that indicates the interference signal to the image quality in quantitative measurements (Bushberg & Boone, 2011) using the eFilm version 2.1.2 200 programs.

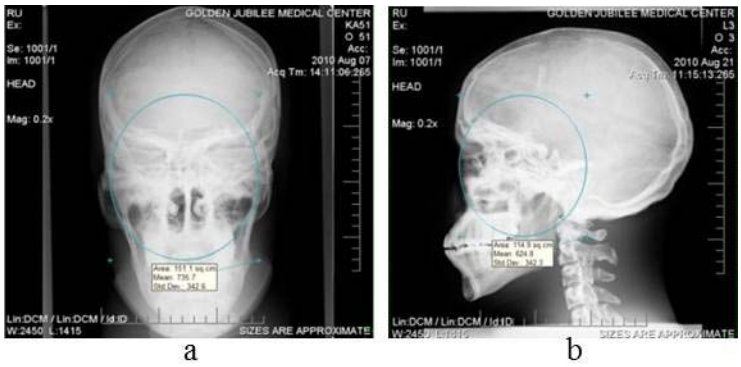

Figure 2 Region of interest (a) skull AP and (b) skull lateral

4. Results and Discussion

In the research, it was found, in both skull AP and lateral x-ray imaging, when using the higher radiation dose, the exposure indicator is decreased, as shown in Figure 3 and 4, respectively.

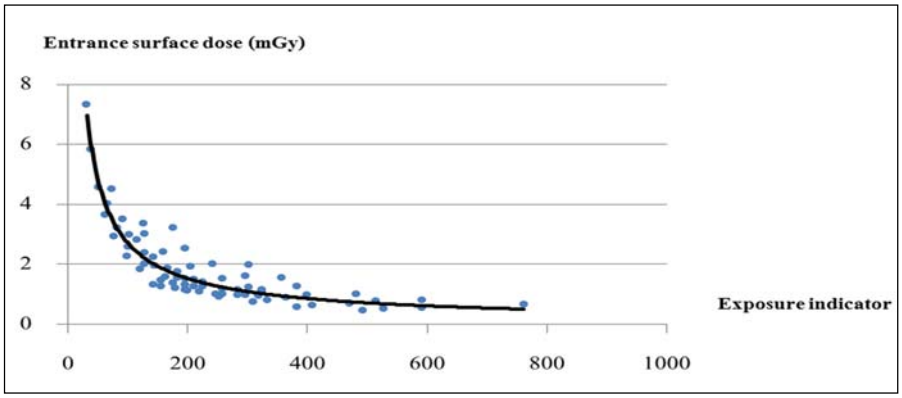

Figure 3 The graph of the relationship between the exposure indicator and the entrance surface dose of the skull AP position. The blue dots were showed the radiation dose at various exposure indicators, and the black line showed the trend of the relationship between the exposure indicator and entrance surface dose

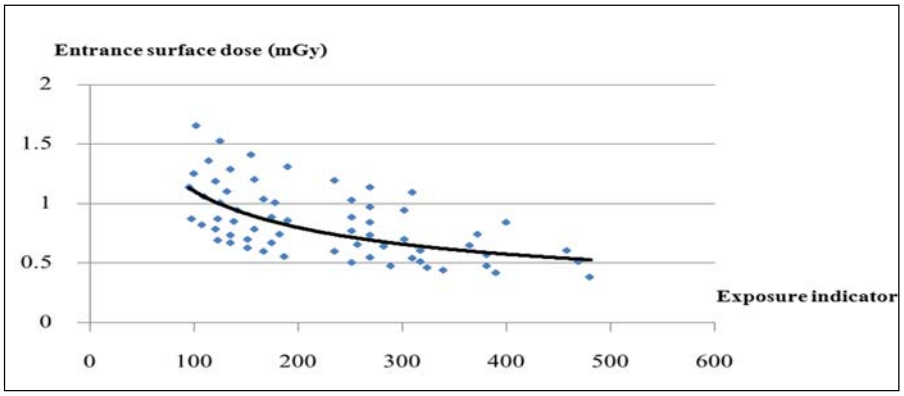

Figure 4 The graph of the relationship between the exposure indicator and the entrance surface dose of the skull lateral position. The blue dot showed the radiation dose at various exposure indicators, and the black line showed the trend of the relationship between the exposure indicator and entrance surface dose

The results of the quality of the x-ray image with an exposure indicator more than 200 assessed by a radiologic technologist. The results showed that the skull x-ray image in AP position has exposure indicators that range from 200-333 with entrance surface dose values ranging from 0.74 µGy-2.01 µGy and the standard deviations in the range of 322.5-371.1 with an average of 339.6, as shown in Table 1.

Moreover, the results of the quality of the skull x-ray image in lateral position has exposure indicators that range from 200-340 with entrance surface dose values ranging from 0.45 µGy- 1.26 µGy and the standard deviations in the range of 299-379 with an average of 328.5 as shown in Table 2. And statistically, comparing the two groups of exposure indicator and entrance surface dose between AP and lateral posture, it was found that there were significant differences at $p < 0.05$

Table 1 The technical parameter in skull AP x-ray imaging

Exposure technique		Exposure indicator	Entrance surface dose (uGy)	SD
kVp	mAs			
75	10	333	0.81	342.6
68	16	325	1.05	355.4
65	20	325	1.15	347.8
72	12.6	318	0.94	333.5
80	8	310	0.74	325.4
66	20	303	1.24	342.9
69	16	303	1.97	352.1
73	12.6	297	0.96	337.2
60	32	297	1.61	354.2
74	12.6	283	0.99	328.6
70	16	283	1.14	350.4
75	12.6	258	1.01	227.7
72	16	258	1.19	335.9
65	25	258	1.52	342.9
80	10	252	0.92	340.7
76	12.6	247	1.01	325.6
60	40	241	2.01	371.1
74	16	225	1.25	341.9
70	20	225	1.40	335.3
78	12.6	220	1.10	323.8
75	16	210	1.28	330.3
72	20	210	1.48	336.2
65	32	205	1.93	346.4
79	12.6	200	1.13	322.5

Table 2 The technical parameter in skull lateral x-ray imaging

Exposure technique		Exposure indicator	Entrance surface dose (uGy)	SD
kVp	mAs			
64	8	340	0.4	342.3
65	8	325	0.46	342.1
62	10	318	0.52	379
60	12.6	318	0.61	337.1
63	10	310	0.54	335.5
52	32	310	1.10	376.1
58	16	303	0.71	333.4
56	20	303	0.83	350.1
54	25	303	0.95	346

Exposure technique		Exposure indicator	Entrance surface dose (uGy)	SD
kVp	mAs			
66	8	290	0.48	333.4
61	12.6	283	0.65	321.3
64	10	270	0.55	318.1
59	16	270	0.74	325
57	20	270	0.85	330.7
55	25	270	0.98	339
53	32	270	1.15	333.5
62	12.6	258	0.67	318.9
68	8	252	0.51	321.2
60	16	252	0.78	321.4
58	20	252	0.89	321.4
56	25	252	1.04	325.6
66	10	236	0.60	309.6
70	8	220	0.53	306.4
57	25	220	1.07	315.7

This study was an experiment in skull model with different biological components from the human skull. Therefore, it is not possible to recommend the exposure technical values to determine radiation dose, such as kVp and milliampere (mA) that should be used in patients. Besides, the results of this study as a guideline for work, it is still necessary to use patient information and work environment. To consider accepting x-rays that have a higher exposure indicator than recommended, such as the emergency case requiring urgent treatment.

This study will serve as a guideline for future research of the research team. The conclusions of this research are preliminary data for research and experimentation in patients and able to use appropriate x-ray imaging techniques

5. Conclusion

The study of the relationship of the exposure indicator and the entrance surface dose showed that the exposure indicator changes with the entrance surface dose. The results found that the digital skull x-ray AP and skull lateral showed exposure indicators of between 200-333 and 200-340. Also, the data will be used as a guideline for human research in medical diagnostic.

6. Acknowledgements

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