



The Effects of Different Collimation size on signal to Noise Ratio (SNR) of Wrist Joint Radiograph PA Projection

Authors

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Abstract

Background: The quality of radiographic image will significantly affect diagnose. One of the factors used to evaluate digital image quality is signal to noise ratio (SNR)^[1]. The use of excessive radiation field or collimation in radiological examination should be avoided in order to reduce the radiation dose^[2]. Additionally, excessive collimation may increase scattered radiation, degrading the image quality^[1]. In previous observations in practice, radiological examination of wrist joint often use large area radiation field. This study aims to determine the effect of the different size of collimation on the Signal to Noise Ratio of Wrist Joint examination

Purpose: To assess the effects of different collimationsize on SNR of wrist joint examination PA projection.

Method: This is quantitative studywith experimental approach, conducted atthe ATRO Bali laboratory. Wrist radiographs were acquired from 6 volunteers. The SNRof each radiograph was calculated with paired T-test on SPSS statistical software.

Result: The data was normally distributed($p > 0.05$),therefore paired-T testwas performed, resulting in $p < 0.05$, which means that there is a significant differenceof SNR in different collimation size of 18x24 cm and 9x12 cm. The mean SNR value of the smaller collimation(9x12 cm)was higher than the larger size (18x24 cm).

Conclusion: There is a significant difference in the SNR value in different collimation size (18x24 cm and 9x12 cm), with smallercollimationsize resulted in a higher SNR.

Keywords: Collimation size, SNR, wrist joint radiograph.

Introduction

X-ray isa type of ionizing radiation that can provide benefits in detecting an illness^[3]. In digital era, computer-based radiographic examination techniques has been developed in order to produce

higher quality radiographs as well as to provide precise diagnosis, known as Computed Radiography (CR). CR is the digitization of images using a photostimulable plate (PSP) for data acquisition^[4]. Digital images acquired with CR will have higher

resolution, providing diagnostic information^[5]. The process of image formation significantly relied on the type of ionizing radiation used^[6]

Generally, the basic image formation on CR imaging includes 3 main steps; exposure, readout and deleting^[7]. Image quality parameters in computed radiography consist of contrast, spatial resolution, and noise. One of the parameters used to measure image quality on CR is signal to noise ratio (SNR). This parameter describes the level of difference between the measured signal and noise. The greater the SNR, the easier the signal and the noise to be distinguished. An overexposed radiograph may have higher SNR but not necessarily contain accurate information related to the object being imaged. *Contrast to noise ratio* (CNR), on the other hand, is a measure of how far the signal can be distinguished from the background. The greater the contrast, the easier the signal will be distinguished from the background. CNR is a ratio between the difference between the signal and background noise^[8].

Collimation setting on the X-ray tube collimator allows the proper adjustment of irradiated area, resulting in the reduction of scattered radiation as well as the radiation dose received by patients^[2]. Excessive collimation, will not only increase radiation dose, but also produce higher scattered radiation. As a result, the level of noise will increase on the radiograph, reducing the SNR. Meanwhile, the appropriate collimation field will cause less noise and high SNR on radiograph^[1].

Wrist joint is a part of upper extremities. A radiographic technique commonly used to diagnose abnormalities on the wrist is wrist x-ray PA, AP and Lateral projections^[1]. The most common projection for wrist joint examination is PA.

This study aims to assess Signal to Noise Ratio of wrist joint PA projections in various collimation sizes. Collimation sizes used in this study are 18 x 24 cm and 9 x 12 cm. Based on the explanation above, the authors are interested to know whether different collimation size will affect the SNR of wrist radiograph PA projection.

Metode Research

This study is quantitative research with experimental approach. The statistical analysis used in this study was paired T-test^[9,10]. The experiment was conducted at the Laboratory of the Academy of Radiodiagnostic and Radiotherapy Engineering (ATRO) Bali. The purpose of this study was to determine the effect of different collimation on the SNR of wrist joint x-ray PA projection.

A total of 12 wrist joint radiographs were acquired from 6 volunteers, with the following exposure factors; 44 kVp, 50 mA and 0.032 s. The position positioning techniques and exposure factors remained the same throughout this study in order to maintain the validity of the data. Each volunteer were exposed twice with large collimation size (18x24cm) and smaller collimation (9x12cm). A total of 30 dots of ROIs were obtained from the resulting radiographs.

The parameters determining image quality in computed radiography consists of contrast, spatial resolution and noise. All of these factors are related to each others^[11]. A good quality image will have high contrast, high spatial resolution and low noise. On the contrary, on the low contrast and low spatial, there will be high noise level, resulting in poor diagnostic quality.

Noise is non desired signal resulting from acoustic signal (sound) and electrical interference. There is no imaging method that works without contrast and no imaging method that is free from noise. If the contrast is low and noise is high, the intensity of random variation due to noise will be difficult to visualize^[11].

One of the parameters used to measure digital image quality is signal to noise ratio (SNR). This parameter describes the level of difference between the signal by the noise. If the signal and the noise can be distinguished easily, this will result in the greater SNR. The following is the calculation for SNR:

$$SNR = \frac{I_s}{\sigma}$$

Where : I_s is a high signal, σ is the standard deviation value of the area around the signal.

List of point Region of Interest (ROI) measurement SNR at Radiant DICOM viewer:



Figure 1 List of measuring ROI point SNR

CNR is defined as the difference between the mean ROI of the object and the mean of the background [12]. Contrast is how far the signals can be distinguished by the size of the background. If the signal is easy to be distinguished from the background, this will result in a higher contrast value.

As ionising radiation can be harmful to health, the use of radiation needs to be monitored, through strict regulation as well as surveillance. In Indonesia, the regulatory body is BAPETEN (Nuclear Energy Regulatory Agency).

According to BAPETEN, the yearly dose limit for radiation workers is 50 mSv (5 rem), while those for general population is 5 mSv (500 mrem). According to the UNSCEAR report, on average each person receive dose of 2.8 mSv (280 mrem) per year. This means that a person will only receive half of the value of the dose limit for the general public.

Research Result

This research was conducted in May 2018 at Bali ATRO Laboratory. The data were obtained by performing wrist joint examination AP projection on 6 volunteers, with IP sized 35x43 cm with variation on collimation size of 18x24 cm and 9x12 cm. The total exposure per volunteers were 2 times, with a wide collimation size of 18 x 24 cm and smaller size of 9 x 12 cm. The total radiographs obtained from the experiment were twelve (12)

radiographs. The following are the comparison of radiographs resulting from smaller and larger collimation.



Figure 3. Wrist radiographs (PA projection) of a volunteer with 2 different collimation

The SNR values were obtained from Radiant DICOM software by placing dots or ROIs (Region Of Interests) on the same anatomic locations in every radiograph, resulting in a total of 30 SNR values. The following picture is an example of SNR measurement on 2 radiographs with different collimation size.

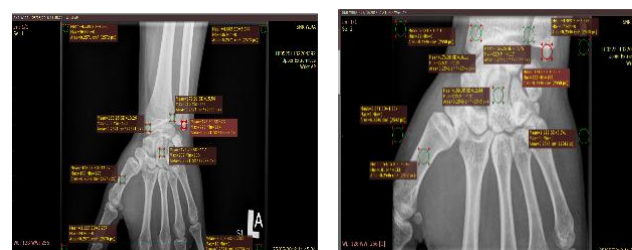


Figure 4. Measurement of SNR in 2 different radiographs with different collimation size in the same volunteer

Once the SNR values have been successfully collected, the data was then tabulated into a table, depending on the size of collimation used to acquire images. The influence of the collimation size on the SNR was analysed statistically by using SPSS software package. Normality test was performed by using Shapiro-Wilk test, with the following results.

Table 1. Normality Test of SNR with Shapiro-Wilk

No.	Field Size collimation.	Value Sig.	Information
1	SNR collimation size 18x24 cm	0,556	Normal Data
2	SNR collimation size 9x12 cm	0,053	Normal Data

Based on the Table 1, the normality test with Shapiro-Wilk shows that both collimation size of 18x24 cm and 9x12 cm resulting in p values > 0.05, which means that the SNR data was in normal distribution. As the data was in normal distribution,

the T-test was then performed to determine whether there is significant difference of SNR values resulting in different collimation size, and to determine which collimation size resulting in a better image quality or higher SNR values. The results of the paired T-test is shown on the following table.

Table 2. Paired T-test of SNR in radiographs with different collimation size

No.	SNR in wide and small field area	Value p / Sig. (2Tailed)
1	SNR in wide collimation (18x24 cm) and small collimation (9x12 cm)	0,001

The statistical test shown in the table 2 indicates that $p < 0.05$, showing that there is significant differences in SNR of wrist radiographs PA projection with different collimation sizes. This means that H_0 is rejected and H_a is accepted.

In order to assess which collimation size will result in a better image quality (higher SNR), the average values of SNR in each category was calculated, presented on the following table.

Table 2. The Mean Values of SNR in different categories

No.	Field Size collimation	Mean value
1	18x24 cm wide SNR collimation	45.2264
2	9x12 cm wide SNR collimation	58.7926

The table 2 shows that the mean value of SNR in radiographs acquired with larger collimation (18x24 cm) was significantly lower than those acquired with smaller collimation (9x12cm), with average values of 45.2264 and 58.7926, for larger and smaller collimation size respectively. This means that a higher SNR was apparent on smaller collimation size.

Discussion

The experiment shows that different size of collimation will result in significantly different SNR, with smaller collimation size resulting in higher SNR. As digital image quality is highly determined by the SNR value, Digital image quality

is determined by the SNR, the higher the SNR, the better the image quality as the signal will be easily distinguished from the noise^[1].

The smaller the collimation size, the better the image quality. The data shows that the mean of SNR with larger collimation (18x24 cm) was 45.2264 whereas smaller collimation size (9x12 cm) resulted in the mean value of 58.7926. The increase in the number of signals generated by Image Plate (IP) will increase the mean value of SNR. High SNR means less noise. Conversely, the fewer the number of signals detected by IP will result in lower SNR. Low SNR means high noise^[11].

The large collimation size, in addition, despite reducing SNR, will also increase the radiation dose to patients. This is because of the increase in scattered radiation, produced by large radiation field. Medical diagnostic imaging aims to produce high quality image with low dose^[15]. The smaller the size of the irradiation field area, the less radiation scattering produced. Therefore, small collimation size is proffered in order to get only high quality image, but lower radiation dose^[16].

Conclusion

Overall, it can be concluded that there is a significant difference in the SNR values of wrist radiographs PA Projection acquired with different collimation size (18x24 cm and 9x12 cm). The use of smaller collimation size (9x12 cm) is preferred as it produces a better image quality, indicated by higher SNR on wrist joint radiograph PA Projection.

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