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Image Quality Assessment of Diagnostic X-ray machines of Different Hospitals in Erbil

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A B S T R A C T

Quality control and quality assurance tests in medical imaging is one of the most vital points in maintaining the image quality of radiographic systems. In order to increase the quality of diagnosis, the QC and QA tests must be performed periodically. The main aim of the project is to assess the image quality of different x-rays systems in different hospitals in Erbil including Par, Sardam, Komari, Rizgari, West emergency and Medya Diagnostic Center. Different image quality parameters such as special resolution, contrast and contrast step wedge have been calculated and inspected using NRT standard test phantom. Its has been concluded that the performance of the x-rays system of Medya Diagnostic Centre is the highest due to the high results of spatial resolution comparing with the other sites. And it also shows that the x-rays system at West emergency hospital has the lowest performance comparing with the other sites. The main reason behind the image quality reduction is lack of operator experience, lack of QC and QA tests and lastly the type of manufacturer and the age of the x-ray machines.

1. INTRODUCTION

X-rays are part of the electromagnetic spectrum with shorter wavelength of visible light and those of UV rays and typically longer than those of gamma rays (Mah, 2001). X-rays are the oldest form of medical imaging that was found in 1895 by William Rontgen in which he received the first Nobel Prize in physics in 1901. X-rays have several applications in the fields of medicine, industry and etc. Most applications of x-rays are based on their ability to pass through matter.
This ability varies with different substances; e.g., flesh is easily penetrated, but denser substances such as lead and bone are more opaque. X-ray imaging system has been widely used in medical imaging and industrial nondestructive testing and other fields. The uses of x-rays in medicine has been greatly improved by continuous innovation and have become more widely applicable for diagnosis and treatment and are of increasing value to the medical world (Mah, 2001).

Since the x-rays are widely used and in many cases are solely taking over the diagnostic judgments in medicine, their quality and performance must be maintained.

The performance of the radiographic equipment are controlled by perfuming quality control procedures on regular basis. This way, the level of diagnostic confidence will be higher and the life time of the system can be extended (De Crop et al., 2012).

Currently, there are a variety of different techniques for the assessment/measurement of image quality. Objective methods, based on the description of the physical characteristics of the image and their relation to the exposure, are usually performed with test-objects and simple physical phantoms. Subjective (or observer performance) methods, based on the visual perception of the whole image or parts of it, are usually performed with anthropomorphic phantoms for medical imaging or with real patient data. (Vodovatov et al., 2017) However, results obtained using the objective methods are more accurate and reproducible; they allow both measuring the primary physical characteristics of the imaging system or the overall system performance. . Unfortunately, establishing a direct relation between those physical image characteristics and clinical image quality is difficult.

On the other hand, the observer performance methods allow evaluating the quality of the whole imaging chain, thus measuring the image quality. Although there is a risk that these methods are influenced by a subjective nature of the observer, they consider the professional opinions and demands of radiologists.

The ongoing, periodic evaluation procedure that called quality control and the purpose of testing is to detect changes that may result in a clinically significant degradation in image quality. If quality control does not take in important it may result defect in diagnosing and make wrong decision from doctors or reporters (Vodovatov et al., 2017).

Quality control in its simplest form is can be taken with phantom that consists of a plate of some kind of material the thickness of which varies in a known manner by radiographing this plate we can determine some image quality parameter such as spatial resolution, contrast details, noise and contrast step wedge that well be used to determine quality of radiography images. Nowadays, different organizations and committees have invented different image quality assessment phantoms that can replace the human body. They can be used daily, weekly, monthly, six monthly and annually depending on the kind of performance test that is used for (Ullman, 2008).

NRT standard test phantom (Fig. 1) that's used in this work was developed by Bengt Nielsen and others and the company Nordisk Roentgen Teknik A/S that used for optimization and quality control of X-ray equipment. The phantom consists of an 8 mm thick sheet of plastic material containing a number of objects in different materials, mainly metals. Each piece of metal that's is built in the phantom used for evaluating different image quality parameters visually and quantitatively which this can be linked to the system capacity (Liang and Weller, 2016). The present phantom provides answers to the image's spatial resolution, contrast, and contrast-detail values, respectively.

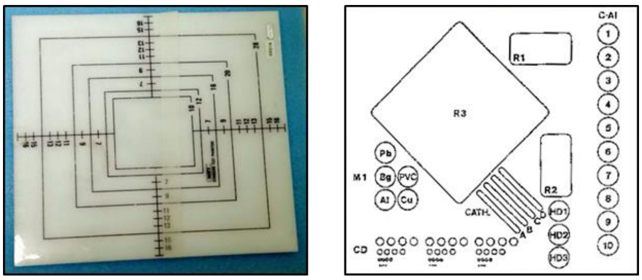

Figure 1: NRT test phantom and the its schematic diagram

In x-ray image quality assessment, there are several measurements of image quality, most in some way related to an image's basic characteristics; contrast, sharpness and noise. Resolution is a measure of the ability to distinguish two adjacent lines or objects. The resolution is often tested with test objects containing line pairs which gives high or low contrasts. High contrast races consist of what so called line pairs which is obtained from a lead followed by an equally wide range. In low contrast rays other materials are used to give lower contrast between the lines pairs. The lines flow into the image then the blur of them opposite edges coincide and thus the contrast decreases to an undetectable level (Liang and Weller, 2016).

Contrast is the degree of density difference between two areas on a radiograph. Contrast makes it easier to distinguish features of interest, such as defects, from the surrounding area. Contrast describes the intensity differences in the image. Intensity is defined as absorbed energy per unit surface of the detector, but constitutes it digital image of grey scale values. The greater the difference is in grey scale value between an object and its surroundings, the greater is contrast (Ullman, 2008).

2. MATERIALS AND METHODS

In this project, the image quality of different x-ray machines of different sites in Erbil have been assessed using NRT test phantom (Fig.1).

For this purpose, the x-ray machines form the hospitals including; Par, Sardam, West and East emergencies, Komari and Medya Diagnostic Center have been taken for assessment and the procedure is shown in figure 2.

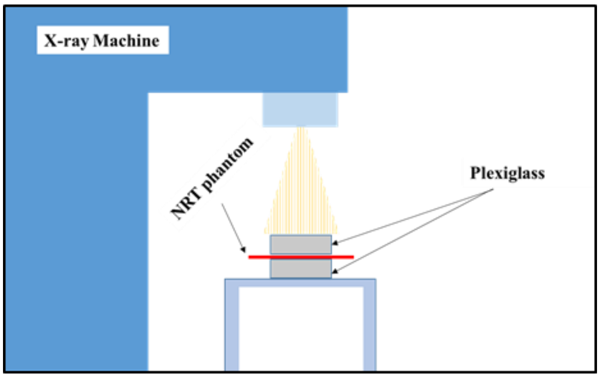

Figure 2: The project setup

The test phantom is placed between 2 block of 6.1 cm thick plexiglass pieces (Fig.3) to give approximately the same attenuation and proliferation of X-rays as an adult patient.

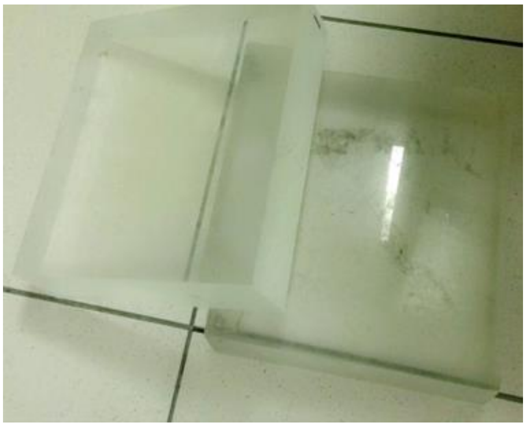

Figure 3: The pair of plexiglasses

A 20 x 20 cm^2 beam field is set on the test phantom and the screening is started when the KV and mAs was fixed on 73 and 32 for all the sites. The following image quality parameters are recorded are for each data set from each hospital:

1. Resolution:

Resolution grids located in different angles with dissolution values from 0.5 to 10 Lp /mm. Rastren is built of thin lead plates pierced by narrow ones slots. Because the lead absorbs X-rays while the gap, on the other hand, permits forming line pairs in the image consists of darker and lighter lines.

2. Contrast-Details

Contrast details with different contrast and size. To give different contrasts in the picture, there are these of drilled holes in different size, grouped by diameter. Which plots are discernible due to contrast, resolution and noise which makes that they constitute an overall image quality test.

3. Contrast step wedge

Contrast step wedge with ten aluminium trays in decreasing thickness. The thickness of each tray determines how much of the radiation that is attenuated, which gives 20 plots with different contrast values in the image.

Each of the above parameters assess the x-ray machine performance differently and Symbolized differently on the NRT standard test phantom.

Table 1: NRT phantom visual analysis protocol

Quality parameters	Explanation	Symbol on the Phantom
Resolution	Number of Lp/mm (The more the better)	R3
Contrast details	Number of row seen in each groups of dots (The smaller seen the better)	CD
Contrast step wedge	Number of apparent circles (The more the better)	CSW

3. RESULTS AND DISCUSSION

After the NRT test phantom has been exposed to x-rays in different hospitals, different images have been obtained depending on the quality of the device in each site. A sample of the image of NRT phantom under x-rays has been shown in figure 4.

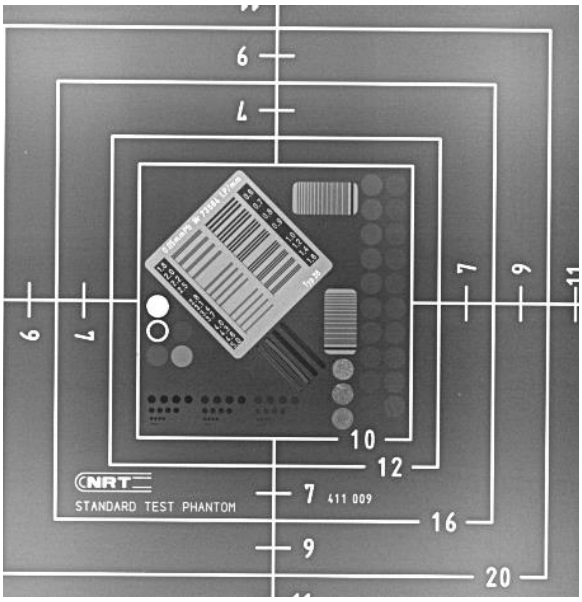

Figure 4: NRT test phantom under x-rays

Table 2: Image quality parameters form different x-rays equipment

Image quality parameters	Hospitals in Erbil					
	Par	**Sardam**	**MDC**	**Komari**	**West Emergency**	**Rizgari**
Spatial resolution (R) (LP/mm)	2.8	2.5	3.7	2.8	2	3.7
High contrast details (HCD)	4	4	4	4	4	4
Medium contrast details (MCD)	4	4	4	4	4	3
Low contrast details (LCD)	3	2	2	2	2	2
Contrast step wedge (CSW)	20	19	18	20	18	11

Each of the above sites are using different radiographic systems as shown in table 3.

Table 3: Diagnostic x-ray machines of different hospitals in Erbil

PAR	Sardam	MDC	Komari	West Emergency	Rizgari
GE (ALO1C11) July 2012	Won Solution (WSR90C) March 2014	Siemens Axiom Iconos 2007	Komari ECO RAY (E7252X) July 2014	Shimadzu (P18DE-85) August 2012	Shimadzu (R-20J) Jan 2014

From table 2, all the obtained date will be compared for each of the image quality parameters:

1. Spatial resolution:

Spatial resolution is the ability of the system to distinguish between the two lines next to each other. It is noticed that the special resolution of the x-ray machine of MDC and Rizgari is exactly the same and the highest between all the sites. But if we compare the year of manufacturer of both of the machines, the way different in age to have the same resolution.

Even though the x-ray machine of MDC was old but it seems that on an excellent working order. The spatial resolution of the x-ray machine of west emergency hospital seems to be the lowest even though the machine is much newer than the one of MDC and almost the same as the one at Rizgari hospital. The reason may be because of the experience of the technologist since the both of these sites are managed similarly and the QC and QA tests would be applied for both of them if any.

2. Contrast details:

It's obvious that all the systems regardless of age and manufacturer are almost performing similarly except some minor difference at the low contrast details. At the high contrast detectability which can be in the cases of the contrast between the bones and the air all of the systems perform perfectly (Vodovatov et al., 2017). But for the lower contrast, such as the contrast between the water and soft tissues, the x-rays system of Par hospital is the most capable one to all even small differences in the intensities.

Even though the image quality parameter of contrast details all of the systems are clinically acceptable, but within this concept, the system of Rzigari hospital has the least capability to distinguish between medium contrast object such as the soft tissue and inflammation.

3. Contrast step wedge

The contrast step wedge with ten aluminium trays in decreasing thickness. The thickness of each tray determines how much of the radiation that is attenuated, which gives 20 plots with different contrast values in the image (De Crop et al., 2012). The thickest plate can be easily seen due to high attenuation of the x-ray but the attenuation decreases as the thickness of the wedges are decreased which obviously the contrast decreases and the SNR increased.

Form the table above its shown that the x-ray machines of both of the hospitals have detected the most number of Al circles built in to the NRT phantom. The x-ray system of Par hospital is the best in detecting all the Al cirlces in the phantom plate. While again the one of Rizgari hospital is doing the worst however, it’s still clinically accepted. This way it would be very hard give you a good image quality when the image of a low attenuation organs are takes. The reason behind the performance of Par hospitals x-rays system may include the operator experience and the machine itself which is digital and recently manufactured by GE. On the other hand, if we compare all the other results of the other sites, we can notice that all of them give almost the same result, since a circle or two will not impinge the quality of the image.

4. CONCLUSIONS

The main of the project was to assess the images quality of different x-rays systems in several hospitals in Erbil. We found out that the simple NRT standard test phantom can be greatly helpful in indicating the image quality that would directly affect the diagnostic accuracy of the x-ray systems. In the research different image quality parameter calculated visually using the NRT test phantom to evaluate the performance of each of the selected x-ray machines.

According to the (Liang and Weller, 2016) spatial resolution of imaging systems plays a central role in imaging performance evaluation, in which the higher the spatial resolution the sharper the image and the signal to noise ratio.

Based on that, we have given this parameter more weight when it comes to the comparison of the different system. Referencing that, we have concluded that the x-rays system of Medya Diagnostic Center (Siemens/Axiom Iconos) and manufactured in 2003 perform the best between all the other systems and the west emergency’s system performs the worst even the machine is manufactures in 2012 and still of the others are still clinically accepted.

The main points to be concluded are summarized in the following points:

1. The x-rays system of Medya Diagnostic Center is considered the best among all the other x-rays systems since the spatial resolution, the main image quality assessment parameter, is the highest. So that the system has the highest ability to resolve two adjacent objects and the images are sharper.

2. However the spatial resolution of the system at Rizgari hospital is the same as MDC’s system but the other image parameters such as contrast and contrast step wedge is the least among all the sites. The main reason behind that is the lack of operator experience and medically accepted DICOM monitors to read the soft copy of the images which allows you

to manipulate the image when interpreted by the radiologists.

3. Even though Par hospital's x-ray machine is new and manufactured in 2012 and its digital which mean all the unwanted rays and noise are filtered digitally but still the spatial resolution is low compared to the one of Rizgari and MDC. The reason may be due to the lack of the periodic QC and QA tests or improper uses of the machine (tube overheating).

4. The sites that use DICOM monitors to interpret the images have the higher diagnostic accuracy because the radiologists will have the option to manipulate the images.

5. The operator experience is one of the main factors that affect the overall image quality of the x-rays systems.

6. Image quality assessment must be performed periodically to avoid any uncertainties and increase the diagnostic accuracy of radiographic systems.

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