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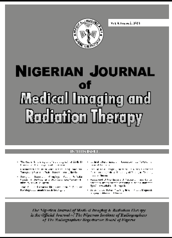

DETERMINATION OF BEAM ALIGNMENT AND CONGURANCE OF RADIATION FIELD AND LIGHT AS PART OF QUALITY CONTROL IN TERTIARY HOSPITALS IN YOLA, ADAMAWA STATE, NIGERIA.

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ABSTRACT

Background: Optimize radiation dose received by patient undergoing x-ray examination is one of the means of reducing radiation exposure. Assessment of x-ray equipment QC parameters is an important practice that ensures high image quality with minimal radiation dose to both patients and personnel. Beam alignment and measure of congruency between radiation field and light field test is a QC parameter that is aimed at reducing repeated exposure by restricting the beam of radiation to the area of interest (optimization).

Objective: The aim is to determine beam alignment and congruency test as part of quality control test in tertiary hospitals yola.

Materials and Method: In this study the beam alignment and perpendicularity were assessed simultaneously on three (3) x-ray machines in three tertiary hospitals in yola Adamawa state using Beam Alignment Test Tool gammex RMI model 162A with serial number 500422-070705, X-ray cassette loaded with films(24*30). The beam alignment test tool and the collimator test tool were placed on and image receptor, and the X-ray field was centered to the center of the tool. The light field was open to the field size of 9 x 7 cm^2, and a radiograph of the test tools was acquired using 60 kVp and 13 mAs at the FFD of 100.

Results: The result of beam alignment test for M-1, M-2 and M-3 are $<1.5^0$, 1.5^0 and $<1.5^0$ respectively while congruency between optical and x-ray field (collimation) the result were 0.3%, 0.2% and 0.2% were all found to be within the limit of $<3^0$and (±2%) respectively.

Conclusion: All the three equipment shows good level of compliance hence there will be no cut off when adequate collimation is applied and dose to patients will be optimized.

INTRODUCTION

Medical exposure remains the largest artificial source of exposure of humans to ionizing radiation [4], in diagnostic images there are several stages involved in image production and at any level there may be errors that can lead to repeat radiograph ranging from equipment error, human error and imaging system which lead to increase dose to the patient and loss of revenue [8].

Radiation dose to patients is a function of radiographic exposure parameters of kVp, mAs, SSD, Filtration and thickness [9].

To optimize radiation dose received by patient undergoing x-ray examination, the parameters of x-ray machine need to be assessed to ascertain their functionality. Hence there is need for maintenance and evaluation of the exposure parameters of the x-ray machines to ensure radiation protection and radiation dose optimization [7].

Quality Control (QC) is a periodic monitoring of precision or accuracy of equipment [11], a process through which the actual quality performance is measured and compared with existing standards [12] it plays important role in ensuring optimal radiographic density and mechanical safety of equipment, it ensure consistency and reduces cost of production and maintenance. Beam alignment and congruence of radiation field and light, is an important QC parameter carried out on x-ray tube and collimators [11].

According to a study [10] on reject analysis in some radio-diagnostic centers in Benin the result shows that one of the major factor for repeat aside exposure factors is positioning, alignment and collimation errors in the light field or X-ray field misalignment. About 106 out of 719 rejected films were due to collimation error [10].

If the x-ray beam is not perpendicular to the image receptor, the image will be distorted [5]. When the actual size of the x-ray field is greater than that indicated on the collimator control knobs, unnecessary exposure to the patient occurs. Also if the actual field is less than indicated, anatomy of interest may be clipped off from the field of view, necessitating a repeated exposure [6]. For an x-ray machine with poor collimator the radiographer is left with only one choice to open up the beam to cover wide area to avoid cut off which eventually leads to more exposure to the patients

Accurate collimation and beam alignment helps in reducing the amount of scattered radiation to the patient by restricting the beam of radiation to area of interest [4] and also improves the image quality by reducing the amount of scatter reaching the[11] thus reducing the rate of repeat and patient dose.

A lot of researchers have carried out studies on QC practices in some part of Nigeria even in some states in northeastern part of Nigeria [1; 2; 3; 4; 7; 11] but none has is done in any tertiary hospital in Yola. The present study Beam alignment and congruence of radiation field and light were conducted as part of Quality Control test on diagnostic x-ray machines in Yola to optimize radiation protection of patient undergoing x-ray examination.

MATERIALS AND METHODS

Three x-ray machines at the tertiary hospitals where tested for beam alignment and perpendicularity using the beam alignment test tool, details of the machines are shown in table 1 below

Table 1 Specifications of various Machines in the facilities

S/No	Manufacturer	Type of machine	Serial No	Model	Year of manufacture	Date installed	Country of manufacture
Machine 1	Italray	Fixed	20-767-06	GEN+IR20 1/A-C	2006	2017	Made in Italy
Machine 2	Siemens Protec	Fixed	2042	05893404	2010	2011	Made in Germany
Machine 3	American Medithec incorporation AMI – HX	Fixed	2K121150 002-X/HF	HX-50	2012	2014	Made in Japan

Collimator and beam alignment test tool The model 162A Beam Alignment Test Tool is a plastic cylinder 12.25 cm (6 in.) tall with a 1/16" (1.6 mm) diameter steel ball at each end. The steel ball on the top is directly above the one in the base when the tool sits on a level surface. The Gammex 162 beam alignment test tool provides simple test of x-ray beam alignment. When use with collimator test tool beam misalignment of 1% and 2% can be visualized without the need for measuring or calculating

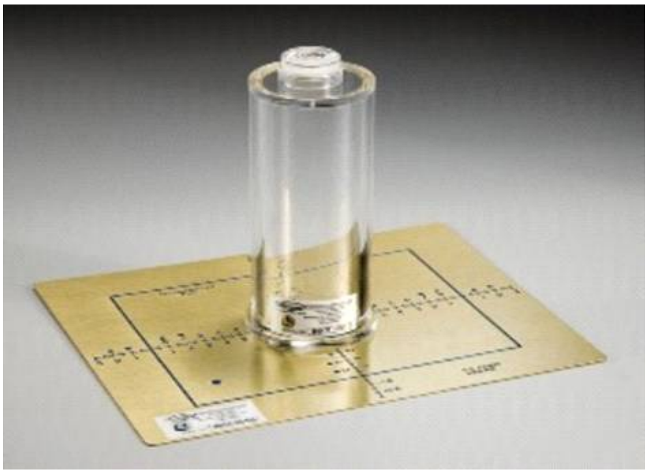

Figure 1: Collimator and Beam Alignment Test Tool

MEASUREMENTS

Beam alignment and perpendicularity test

In this work the beam alignment and perpendicularity were assessed simultaneously using the beam alignment test tool. The beam alignment test tool and the collimator test tool were placed on and image receptor, and the X-ray field was centered to the center of the tool. The light field was open to the field size of 9 x 7 cm^2, and a radiograph of the test tools was acquired using 60 kVp and 13 mAs at the FFD of 100.

RESULTS

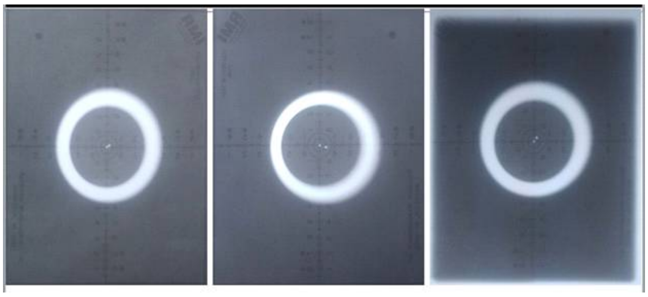

Figure 2; Beam Alignment and Congruency for machines M-1, M-2 and M-3

Table 2 Beam Congruency with Radiation Field

Table 2 shows the result for beam alignment and congruency of radiation field with light field, right and left, up and down indicates the affected side on the radiograph while in or out shows the direction of the movement either in ward or out ward.

Machine	Right		Left		Up		Down	
	In	Out	In	Out	In	Out	In	Out
M-1	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.1
M-2	0.0	0.2	0.2	0.1	0.0	0.1	0.1	0.0
M-3	0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.0

DISCUSSION

Figure 2 shows the radiographs obtained during the procedure for beam alignment and congruency for all the three machines the central point indicates the center of the beam while the other point indicates the degree of misalignment. If the x-ray beam is not coinciding with the light field, the radiation field may be shifted away from the area of clinical interest, which will contribute unnecessary dose to the patient. The misalignment reduces diagnostic image quality and leads to exposure of non-targeted areas and leads to cut off in anatomical area of interest and lead to repeat. It is caused by the shifts in the relative positions of the light bulb, reflecting mirror or anode focal spot. In the normal situation the beam alignment is not always be hundred percent accurate. But, if the beam alignment is less than 1.5^0 or in between 1.5^0 and 3^0 the perpendicularity (alignment) of the x-ray beam is in the acceptable limit. If it moves beyond 3^0, it is not within the acceptable limit [6], based on the result presented in Fig. 2 above shows that machine M-1 and M-3 falls within the inner circle which is less than 1.5^0 while M-2 is on the inner circle which is 1.5^0 and were all within acceptable limits.

The congruency test were carried out to determine the congruency between optical and x-ray field at FFD range of 100cm, constant kVp of 64kVp and 16mAs, the maximum misalignment allowed is (±2%) of FFD [5]. The misalignment was determined when an edge of the x-ray field falls on ±1cm on either side of the line. It shows that the edges of the x-ray field are misaligned by 1% of the distance between the x-ray source and the table top in case of misalignment beyond the tolerance limit also leads to cut-off which can lead to repeat and increase patient dose [4]. Gross misalignment between light and radiation field may lead to wider opening of radiation field to avoid cut-off however the result lead to increase radiation dose to the patient by exposing sensitive areas not under study and implies poor radiation protection practice.

The result presented in table 2 are 0.1%, 0.2% and 0.1% were all found to be within the limit of (±2%) and possess no serious danger to the patients and the result is in accordance with the study conducted by Akaagerger *et al,* 2016 [2],] on Diagnostic X-Ray Machines Quality Control Parameters Analysis in Some Major Hospitals in Benue State Nigeria, The assessment were carried out using Radiographic/Fluoroscopic kit, model Gammex 184D. Three X-ray machines in the Radiological departments were monitored. The quality control Tests employed in this research work includes

Collimator and Beam Alignment Test the result shows that all were within the tolerance of 1.50 from the perpendicular. Akaagerger *et al* 2015[3], conducted a study titled Evaluation of Quality Control Parameters of Half Value Layer, Beam Alignment and Collimator Test on Diagnostic X-Ray Machines in Radiological units of two major Hospitals in Makurdi, Benue State Nigeria, Beam alignment and Collimator test tools. were used to measure the degree of misalignment of the target points. The result showed misalignment of 0.2 cm and 0.6 cm for the two hospitals respectively which means the misalignment falls within the acceptable limit of 2.0 cm as recommended by International Commission on Radiological Protection.

Begum *et al,* 2011[1], conducted a study titled quality control tests in some diagnostic x-ray units in Bangladesh, in which beam alignment, field congruence, were measured from forty different diagnostic x-ray facilities in Bangladesh. For congruence between optical and radiation fields, 77.5% are found to be within limit while the remaining (22.5%) facilities fall outside the limits this situation affect diagnostic image quality and leading to exposure of non-targeted areas. And for beam misalignment, 60% of facilities were within the beam alignment limit. other studies like Ike-Ogbonna *et al,* 2017[7], and Moi *et al,* 2019 [4] also shows varying level of compliance and recommends corrective actions.

CONCLUSION

The result from the study of beam alignment and perpendicularity shows adequate level of compliance, however good x-ray equipment performance are not only a matter of complying with the regulations, but also, the interest in improving the quality and efficiency at the radiology centers.

Conflict of interest: Nil

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