IOSR Journal of Applied Physics (IOSR-JAP)
e-ISSN: 2278-4861.Volume 7, Issue 1 Ver. II (Jan.-Feb. 2015), PP 11-15
www.iosrjournals.org

Determination ofRadiological Quality Parameters Using Optical Densitometer andSimple Fabricated Equipment

Kpaku Goriya[1],Abdullahi Mundi[1], Aribisala Abdul-Jamiu[2], Peter Eshiett[3],Richard Itopa[4],DlamaZira Joseph[5],

1. *Physics Department, Nasarawa state university Keffi, Nigeria*
2. *FCT Secondary Education Board, Abuja, Nigeria*
3. *Federal Medical Center Keffi, Nigeria*
4. *Department of Radiography, Bayero University Kano*
5. *Radiology DepartmentAbubakarTafawaBalewa University Teaching Hospital Bauchi, Nigeria.*

CORRESPONDING AUTHOR'S EMAIL[5]:josephdlama@gmail.com

Abstract: *The etiquette of safe practice for the use of x-rays in medical diagnosis requires that each x-ray facility has an appropriate quality assurance program in radiation protection and to keep doses as low as reasonable achievable. An alternative method of evaluating radiological quality parameters of diagnostic x-ray machine is considered in this study. This study was conducted in Federal Medical Center Keffi, Nasarawa State. The aim was to determine radiological quality parameters using optical densitometer and simple fabricated equipment. This research has determined some of these parameters via the wooden step wedge and metal pin fabricated. The wedge and metal pin were exposed to x-ray and the optical densities of the processed films were measured with a densitometer. The result indicates that simple fabricated equipment can be used to determine the following radiological quality parameters such as dose, beam alignment, peak kilo voltage and tube current consistency in the absence of quality control test equipment. This is an indication that departmental protocol can be established in x-ray department using simple fabricated equipment .These equipment can be used in the determination of radiological quality parameters.*

Keywords:[*Radiation Protection, Parameters, Optical Densitometer,Diagnostic, Equipment.]*

I. Introduction

Diagnostic radiology machines have been of great help to health care industry and many people have benefited from the useful information they provide[1]. Providing standard health care infrastructure is one of the priorities of modern-day hospital in our country[2]. The investment in state –of the art equipment is vital in achieving this goal. It is essential to maintain the quality of high-end equipment procured to provide high quality health care. One of the difficult areas of maintaining this infrastructure is within the diagnostic radiology department[2],[3].

Radiation cannot be seen, heard or smelt hence, to check the quality of radiation producing equipment, intuitive methods of detection seldom fail[4]. Checking the quality of the image might give an indication of optimal performance of radiation equipment, but can be often misleading[4]. The quality of diagnostic radiation equipment directly affects the image quality and unwanted exposure to staff[5]. Poor diagnostic image quality can lead to diagnostic dilemma[5].

II. Materials And Methods

The materials used for this study include

- X–ray machine
- Densitometer
- Wooden step wedge
- Uniform metal pin
- Radiographic film (Kodak)
- Micrometer screw gauge
- Verniercaliper

2.1X–ray Machine

Characteristics of the x–ray machine include

- Tube voltage, 125kv
- Total filtration, 2.9mmAl/70kv

- Tube serial number 8324/12
- Model number XD52–30.50/125–T2A

2.2 Densitometer

Characteristic and specification of densitometer

Point densitometer is straight forward device used for determining the optical density (OD) at a few points in a film. This device is easiest to QA for absolute OD and is therefore often used as the local standards in OD measurements. Point densitometer use a silicon photodiode to measure the transmitted flux of light passing through a film. The international organization for standardization (ISO) has developed standards for the geometric and spectral conditions for the determination of optical density (ISO,5) Diffuse illumination is achieved by a broad–spectrum, incandescent lamp whose spectral properties conform to international commission on illumination (CIE) standards. The collimated light passes through the film and the transmitted component passes through a detecting aperture that usually can be from 1–3mm in diameter. This light flux passes through a V- filter (555nm peak – 780nm range) and is then detected by a silicon photodiode with amplifier electronic capable of measuring signals spanning several orders of magnitude. This system consist of a backlit tablet with light aperture on which one places the film sample, an arm which extends over the film and has at its end the light source aligned with the aperture and a digital readout of optical density (Sujatha, 2007).

2.3 Construction

Iroko wood was obtained in the form of rectangular block of dimensions. Light, L = 10cm, width, w = 3.5cm, height, H = 3cm, mass, m = 25g, volume, v = 65cm^3. The construction was carried out at kpakurium workshop in Keffi, Nasarawa State. The wood was machined to square using the plane jack, to smoothen out rough edges and make the surface uniformly smooth throughout. Five steps of equal thickness and height were marked on the wooden block with pencil, to aid accuracy in cutting the steps. The difference in thickness between each step is 0.6cm (Martins, 2007).

2.4 Exposure Procedure

- The wooden step wedge was placed on a 24 x 30cm cassette, a control exposure was made by keeping the mAs constant at 16mAs and varying the kVp, thus 45, 50, 55, 60, 65 and 70kVp respectively at constant film to focus distance (FFD) of 100cm, a total of six exposure were made.
- The same procedure was repeated by keeping the kVp constant at 45kVp and varying the mAs, thus 2, 4, 6, 8, and 10mAs respectively at constant FFD of 100cm, a total of six exposure were also made in this case.
- Film processing, this was done in the dark room with only the safe light on. The exposed films were removed from the cassettes and processed temperature of 0.3 degree Celsius. After processing and drying, the film was assessed on the view box, all the steps of the wedge were visible.

2.5 Measurement of optical density

The measurement of optical density (O.D), was carried out using the transmission digital densitometer x–rite 331 nickel–cadmium (Nicad), battery operated (600/700mAhr). For the constant 16mAs films with the images of the wooden step wedge, the optical densities of the five steps were measured for the constant 45kVp film with the images of the wooden step wedge, the optical densities f for five steps were measured.

2.6 Simple beam alignment test

A uniform metal pin of thickness 0.3cm, length 10cm was mounted 90^0 vertically on a rectangular block of wood 2 x 4cm and 0.5cm thick. The metal pin was placed on a cassette and expose to x–ray using a suitable exposure factor (4mAs x 50kVp) and FFD of 100cm (Glen, 1993). The tolerance angle () was calculated using trigonometry ratio (tan = a/b).

The length of the image of the metal pin was traced on the x–ray film with a divider and a meter rule. The length of the metal pin and that of the image form two side of a triangle. With these information, the tolerance angle was calculated as shown in the

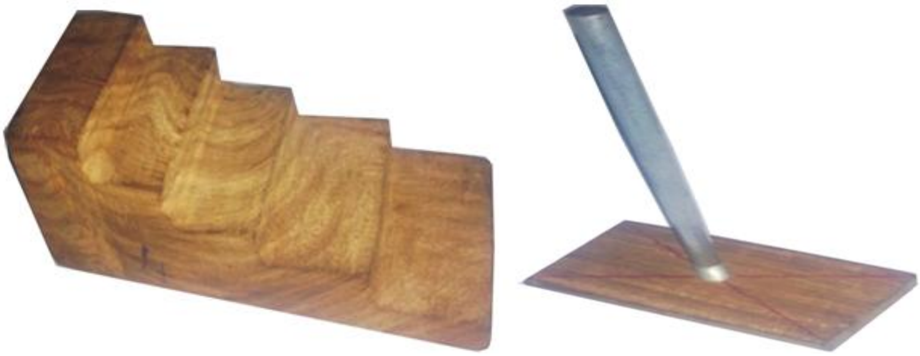
2.7Statistical Analysis

In order to determine the effect of kVp and mAs on dose, a graph of these two parameters was plot against optical density using the Microsoft Excel and the SPSS Statistical Package

III. Results

3.1 Fabricated Wooden Step Wedge and Metal Pin

Five steps wooden wedge and 10cm metal pin were fabricated and used to determine the radiological quality parameters. The fabricated equipment are shown in figure 3.0 below



- **Wooden step wedge**

(b) Metal Pin

Figure 3.1: simple fabricated equipment

Figure 3.2: radiograph of wooden step wedge at 16mAs and varying kVp

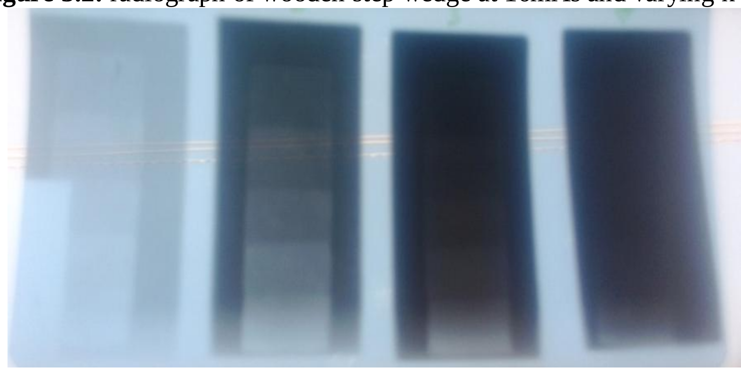


Figure 3.3: A graph of optical density against thickness.
Figure 3.4: A graphof tube charge against optical density.

Table 3.0: Relationship between Optical Density and Dose .

S/N	Optical density	Dose(Gy)
1	0.74	0.754
2	0.69	0.748
3	0.67	0.746
4	0.60	0.743
5	0.58	0.721

Table 3.1: Simple Beam Alignment Test

	1	2	3	Average
Length of metal pin(a)cm	10.00	10.00	10.00	10.00
Length of image(b)cm	0.20	0.30	0.20	0.20
Tolerance angle (degree)	1.14	1.70	1.14	1.32

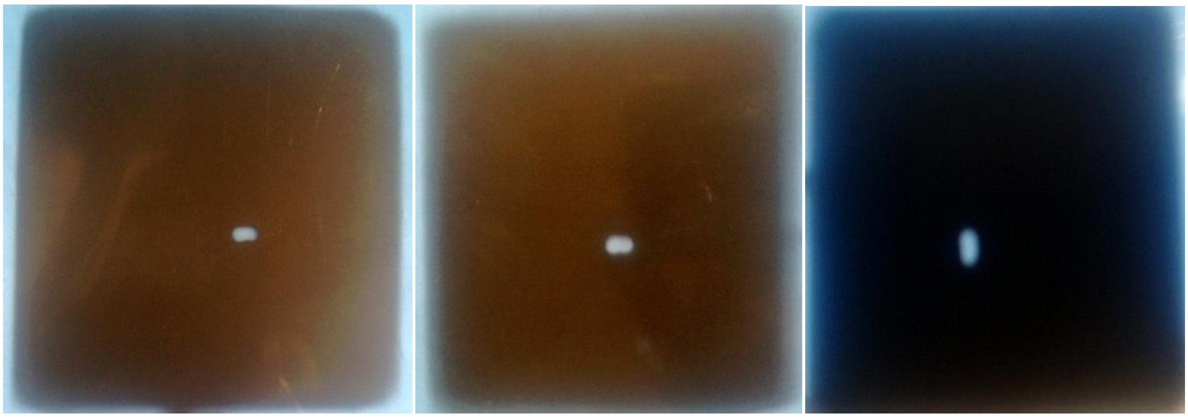


Figure 3.5: Radiograph of 10cm metal pin

IV. Discussion

The result from this study shows that, simple fabricated equipment can be used to determine radiological quality parameters .This is useful in diagnostic radiology where quality control (Q C) test equipment are not available.

The step wedge method of checking the consistency of peak kilo voltage and tube charge of diagnostic x-ray machine does so in terms of optical density which represents the total exposure reaching the film and producing the image.

A common problem among the hospitals in Nigeria is the lack of regular patients dose monitoring and quality control in diagnostic radiology. A major reason for this is the cost of running a standard radiation protection and quality assurance on the facilities.[8],[9],[10].

Figure 3.1 shows that at constant 16 mAs using the fifth step of the wedge ,as the kVp of the x-ray machine increases ,there is also an increase in optical density ,which confirm the relational equation between optical density and kVp which is $O.D=C(kVp)^n$. From the graph (figure3.1) the power n is 2.997 and the constant value is C is 4×10^{-6}, which is within the recommended limit[15][16]. This is an indication that the kVp is consistent. This is in consonance with a study done by using aluminum step wedge in Jos university teaching hospital[13][15][18].

Figure 3.2 shows that optical density decreases with increase in thickness, the higher steps of the wedge are dense, thus absorb more radiation than they transmit. The lower steps on the other hand are not as thick and hence readily transmit radiation, absorbing none at all. This implies that attenuation increase with increase in thickness.[16],[19].

Figure 3.3 shows that at constant 45kVp as the tube charge increases, the optical density also increases .Higher values than 8mAs has higher optical density, but poor image contrast, this may be due to excessive dose. This implies that optical density is directly proportional to tube charge, which confirm the relational equation between optical density and tube charge.($O.D \alpha mAs$).

Table 3 shows the relationship between optical density and dose which is obtained from linear path of the curve of a graph of optical density against thickness (figure 3.3). $Y=0.077X+0.8$ is the equation of the linear path of the curve, where Y is the dose and X is the optical density. The doses were obtained by substituting the values of optical density into the equation .The result obtained as presented in table 3, shows that as the optical density increases, dose also increases. This indicate that optical density can be use to estimate dose[16],[17].

Table 3.1 shows the average tolerance angle obtained from the simple beam alignment test which is 3^o.This implies that the x-ray beam of the machine is aligned since the tolerance angle is within the recommended range ±5 [15],[17].

V. Summary of the Study Finding

- As kVp of the x-ray machine increases, there is also increase in optical density. This implies that optical density is directly proportional to kVp. It means that change in potential can cause drifts in beam intensity and thus significantly influence radiation dose and image quality as well as after the film density.
- As the tube charge of the x-ray machine increases, there is also increase in optical density. This implies that optical density is directly proportional to tube charge.
- The optical density of the higher steps, are less than those of the lower steps. This implies that attenuation increases with increase in thickness, it indicate that optical density is inversely proportional to thickness.
- As the optical density increases dose also increases. This implies that optical density is directly proportional to dose
- The tolerance angle obtained from the simple beam alignment test is 3^o,which indicate that the x-ray machine is properly collimated and the beam is aligned
- The following quality parameters were found to be consistence; kVp ,mAs, dose and beam alignment.

VI. Conclusion

The result from this study shows that simple fabricated equipment can be used to determine radiological quality parameters, such as; dose, beam alignment, kVp and mAsconsistency.This implies that, if the diagnostic x-ray machine is not maintaining the consistency of this parameters, it's output will be poor.

References

[1]. Ash, D & Bates, T. (1994) Report on the Clinical Effects of Inadvertent Radiation under Dosage in 1045 Patients, Clinical Oncol. World Journal of Medical Sciences 6:214 – 225.
[2]. Akpa, T.C. (2013). Interaction of Radiation with Matter. A Lecture note on, Radiation physics, Nasarawa State University, Keffi (unpublished).
[3]. Attix, F. H. (1986). Introduction to Radiological Physics and Radiation Dosimetry. Wiley, New York PP56
[4]. AERB Safety Code. (2001). Code No. AERB/SE/MED- 2, Mumbia PP 1 -20.

[5]. Bushong, S.C. (1993). Radiography Science for Technologist Physics, Biology and Protection. 5th Edition. St Lovis; Mmosby Year Book PP45-70

[6]. Beacomfield, T., Nicholson, R., & Thornton, A. (1999). Would Thyroid and Breast Shielding be Beneficial in CT of the Head? Eur-Radiol. World Journal of Medical Sciences. 8(4), pp664.

[7]. Christian Nordgvist (2011).Effect of Radiation on Human http://www.medicalnewstoday.com/articles/2.1965.php.

[8]. Curry, T. S., Dowdey, J.E& Marry, R. C. (1984). Introduction to Physics of Diagnostic Radiography 3rd Edition. Lea and Fibiger, Philadelphia, PA pp88 – 106.

[9]. Edmonds, I.R. (1984). Calculation of Patient Skin Dose from Diagnostic x-ray Procedure. British Journal of Radiology, 57, 733 – 734.

[10]. Egbe, N.O., Inyang, S. O &Eduwem, D.U. (2008). Doses and Image Quality for Chest Radiograph in three Nigerian Hospitals. European Journal of Radiography 1, 30 – 36.

[11]. Golani industrial complex waliv, vasai (2013).In house Quality assurance of diagnostic radiology Equipment. www.raysafe.com.

[12]. HananFawaz. (2007). Assessment of Entrance Skin Dose and Effective Dose of some Routine X-ray Examination using Calculation Technique.www.geogle.

[13]. International Commission on Radiological Protection (1996). Protection and Safety in Medicine, Publication 73, Pergamon Press, Oxford.

[14]. John & Brenan. (2000). Reference Dose level for Patients undergoing Common Diagnostic x-rays Examination in Irish Hospital. British Journal of Radiology 73, 396 – 402.

[15]. Mangset, W.E. &Izang, N. (2010). Locally Fabricated Metal Step Wedge for Quality Assurance in Diagnostic Radiology. Department of Physics, University of Jos. Bayero Journal of Pure and Applied Sciences, 3(1); 156 – 163

[16]. Martin, C.T. (2007). Optimization in General Radiography www.biij.org/2007/2/e/8

[17]. Nworgu, O. D &Bamidele, L. (2010). An Evaluation of Entrance Surgace doses from some Common Diagnostic x-ray Examinations in two Nigerian University Teaching. Journal of Radiological Protection Vol. 29, N2a, 952-4746.

[18]. Rehani, M.M.(1995). Diagnostic Imaging Quality Assurance. Jaypee Brothers Medical Publisher.New York, pp45.

[19]. Sujatha, P. (2007). Radiographic Film for Mega Voltage Beam Dosimetry. Radiation Therapy Department, Memorial Hermann Hospital, Houston. Texas 77024, pp2239.

[20]. Sato, O., Iwai, S &Farihata, S. (1995). Calculation of Equivalent Dose and Effective Dose Conservation Coefficients for Photon. Radiation Protection Dosimetry. Nuclear Technology Publishing, Japan, Vol.62, No. 3, pp119 -130.