Sudan University of Science and Technology

Collage of Graduate Studies

Assessment of Collimator Accuracy for X-Ray Machines in Khartoum State

تقييم دقة المحدد لأجهزة الأشعة السينية في ولاية الخرطوم

A thesis submitted for partial fulfillment for the requirements of master degree in medical physics

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February 2016

الاية

قال تعالي:

(وَاصْبِرْ نَفْسَكَ مَعَ الَّذِينَ يَدْعُونَ رَبَّهُم بِالْغَدَاةِ وَالْعَشِيِّ يُرِيدُونَ وَجْهَهُ وَلَا تَعْدُ عَيْنَاكَ عَنْهُمْ تُرِيدُ زِينَةَ الْحَيَاةِ الدُّنْيَا وَلَا تُطِعْمَنْأَ غْفَلْنَا قَلْبَهُ عَن ذِكْرِنَا وَاتَّبَعَهَوَاهُوَكَانَأَمْرُهُ فُرُطًا)

صدق الله العظيم

سورة الكهف الآية(28)

Dedication

- To my lovely parents and family, my mother that candle that burn to light others life.

- My father who did the best he can to make me what I become.

- To my family’s love, patience, support and care were essential all the time to accomplish this search

- To my friends and my colleagues

I dedicate this work to you

Acknowledgment

First of all I would like to thanks Allah who’s without his mercy, blessing and his kind to me I was never be able to begin and finish this work.

Then I would like to express my sincere gratitude to my supervisor

Dr: Hussein Ahmed Hassan for his suggestions, patient, guidance, encouragement, cooperation and supervision of this work.

Iam also so grateful to every person helped me in gathering information and guiding me in making this project.

Abstract

The lack of QC program contributes to the image quality deterioration, with the consequential increase in wasting of films and repetition of imaging studies, thus increase the radiation exposure for both patients and worker

This study was aimed to evaluate of collimator accuracy of x-ray machine in Khartoum state hospitals, the study include 10 x-ray units from different radiology department in Khartoum state hospitals tested by 8 coins placed in the edges of the light field and one in the anode direction, which was opened so as to visually observe the light field and exposed to x- radiation using exposure factors of 50kV, 100mA ,0.5s and processed for images of the alignment of the light field to the x-ray field and processed. And the measurements were made with the meter rule.

Our study showed that there is high percentage of light field and x-ray field congruence about 70% and lower percentage of misalignment 30% and x-ray beam central is alignment with the cassette holder. Finally the future study must be large case for QA programs and contains all QC tests for x-ray machines.

: ملخص البحث

عدم توفر برنامج ضبط الجوده يساهم في تدهور الصورة ممايؤدي الي تكرار عملية التصوير واستهلاك الكثير من الافلام؛ويصاحب ذلك زياده في التعرض للاشعاع بالنسبة للمرضي والعاملين .

الهدف من هذا البحث هو تقيم دقة المحدد لاجهزة الاشعة السينية لمستشفيات ولاية الخرطوم شملت الدراسة عدد 10 اجهزة اشعة سينية من مختلف اقسام الاشعة

السيينة في مستشفيات ولاية الخرطوم وتم اداء الدراسة بوضع عدد 8عملات معدنية علي حواف مجال الضوء وواحدة في اتجاة الانود وفتح المجال حتي توضح رؤيتة ثم عرضت العملات الي الاشعة حسب عوامل التعرض 50kvو 100mA و 0.5s وتمت معالجة الصوره واخذت قراءات التطابق بواسطة اداة القياس المسطره ؛ووجد ان هنالك نسبة عالية من التطابق بين مجال الضوء والاشعة تصل الي 70% ونسبة عدم التطابق 30% وان هنالك تطابق تام في كل الاجهزة في تمركز الاشعة .واخير الدراسات المستقبلية يجب ان تشمل كل برامج تاكيد الجوده وان يتم اجراء كل اختبارات ضبط الجوده لاجهزة الاشعة السينية .

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List of abbreviation

QA : Quality Assurance

QC: Quality Control

SID: Source to image distance

HVL: Half value layer

LBDs: light beam diaphragms

FFD: focal film distance

CRCPD's: Conference of Radiation Control Program Directors

AAPM: American Association of physicists in Medicine

AL1 + AL2: Total along cassette misalignment in cm

AC1 + AC2: Total across cassette misalignment in cm

1. Chapter one

1.1 Introduction:

In medicine, radiological images are utilized as an aid to diagnosis, treatments and also in images-guided procedures. For such purposes, the image must meet a certain level of quality, so as to minimize errors of interpretation and identification of structures, thus allowing an accurate diagnosis with low radiation levels. Otherwise a low quality image causes the repetition of imaging studies and, consequently, the duplication of radiation dose in the same patient, besides additional costs to the radiology service (A C Mendeset al, 2009). The reduction of radiation dose to the patient and effect of secondary radiation on the image contrast is achieved by use of x-ray beam collimators. The effectiveness of collimation by these beam collimators is strongly dependent on the accuracy with which the x-ray beam is centered to the anatomical area of interest. An infinite variety of field shapes and sizes give the opportunity of optimum protection and image contrast in all situations enhancing quality assurance (*N. O. Egbe et al , 2003*). This however, fails to be the case when changes in the features of these collimators occur, providing observable difference in its function. It is therefore useful to consider the consequences of an undetected error which occurs as a result of misaligned radiolucent light reflecting mirrors or other sources of error in a light beam diaphragm, which forms part of modern x-ray equipment and functions in providing a visible demonstration of beam centering and the field shape and size. Knowledge of these possible errors enhances the applicability in the patient radiation dose control. (*N. O. Egbe et al, 2003*). The limitations of a light beam diaphragm become obvious when the lamp fails or the mirror is dislodged from its precise position. Even after wise precautions are carried out to lessen these failures, they could still occur hence regular checks are recommended after repairs, or maintenance work on the x-ray equipment for quality assurances.,. (*N. O. Egbe et al , 2003*).Occasionally, the mirror of a light beam diaphragm goes out of alignment so that the light and x-ray fields no longer coincide. This usually leads to problems of geometry in the emerging beam of radiation with the attendant effects on image quality and even radiation dose to the patient (*N. O. Egbe et al , 2003*). The present study was aimed at assessment the light and radiation fields' congruence and radiation beam alignment in medical X-ray equipment in Khartoum state.

1.2 problem of the study:

Improper alignment of collimator increase radiation dose to the patient and reduce image quality, Misalignment may result in unnecessary the anatomical area in the patient or repeat exposure

1.3 Objective of the study:

1.3.1 General objective:

Assessment of collimator accuracy for x-ray machine in Khartoum state

1.3.2 Specific objective:

1-assure the light diaphragm accuracy

2-assure the perpendicular x-ray beam incident the patient

3-to reduce radiation dose to patient

1.4 These are layout:

This study composed of five chapters, chapter one is introduction, problem of study and objective, chapter two background and pervious study, chapter three material and methods, chapter four results and chapter five discussion, conclusion and recommendation.

2. Chapter two

Literature review

2.1 backgrounds:

X-rays are produced when highly energetic electrons interact with matter and convert their kinetic energy into electromagnetic radiation. A device that accomplishes such a task consists of an electron source, an evacuated path for electron acceleration, a target electrode, and an external energy source to accelerate the electrons. Specifically, the x-ray tube insert contains the electron source and target within an evacuated glass or metal envelope; the tube housing provides shielding and a coolant oil bath for the tube insert; collimators define the x-ray field; and the generator is the energy source that supplies the voltage to accelerate the electrons. The generator also permits control of the x-ray output through the selection of voltage, current, and exposure time. These components work in concert to create a beam of x-ray photons of well-defined intensity, penetrability, and spatial distribution. (JERROLD T et al, 2002.)

2.2 PRODUCTION OF X-RAYS:

2.2.1 Bremsstrahlung Spectrum:

The conversion of electron kinetic energy into electromagnetic radiation produces x-rays. A simplified diagram of an x-ray tube. A large voltage is applied between two electrodes (the cathode and the anode) in an evacuated envelope. The cathode is negatively charged and is the source of electrons; the anode is positively charged and is the target of electrons. As electrons from the cathode travel to the anode, they are accelerated by the electrical potential difference between these electrodes and attain kinetic energy. The electric potential difference, also called the voltage, is defined in Appendix A and the SI unit for electric potential difference is the volt. The kinetic energy gained by an electron is proportional to the potential difference between the cathode and the anode. On impact with the target, the kinetic energy of the electrons is converted to other forms of energy. The vast majority of interactions produce unwanted heat by small collision energy exchanges with electrons in the target. This intense heating limits the number of x-ray photons that can be produced in a given time without destroying the target. Occasionally (about 0.5% of the time), an electron comes within the proximity of a positively charged nucleus in the target electrode. Columbic forces attract and decelerate the electron, causing a significant loss of kinetic energy and a change in the electron's trajectory. An x-ray photon with energy equal to the kinetic energy lost by the electron is produced (conservation of energy). This radiation is termed bremsstrahlung, a German word meaning "braking radiation."The probability of an electron's directly impacting nucleus is extremely low, simply because, at the atomic scale, the atom comprises mainly empty "space" and the nuclear cross-section is very small. Therefore, lower x-ray energies are generated in greater abundance, and the number of higher-energy x-rays decreases approximately linearly with energy up to the maximum energy of the incident electrons. A *bremsstrahlung spectrum* depicts the distribution of x-ray photons as a function of energy. (JERROLD T et al, 2002.)

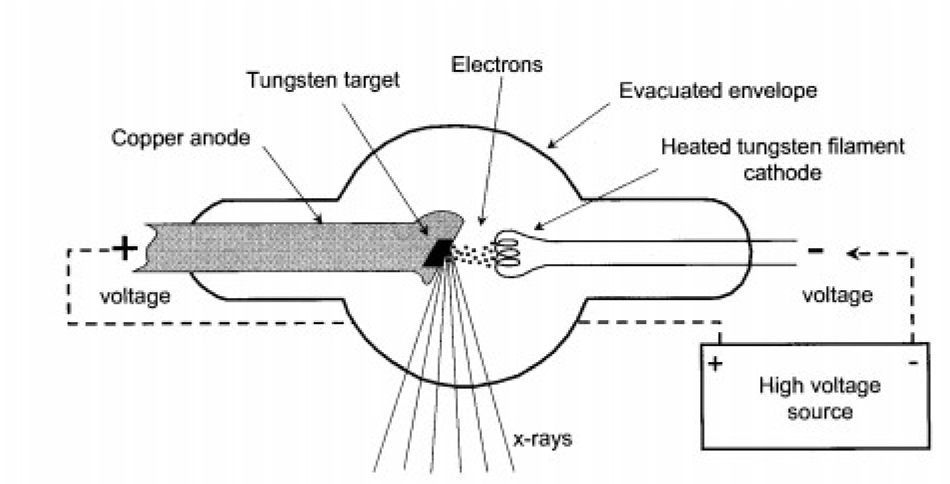


Figure (2.1) Minimum requirements for x-ray production (JERROLD T et al, 2002.)

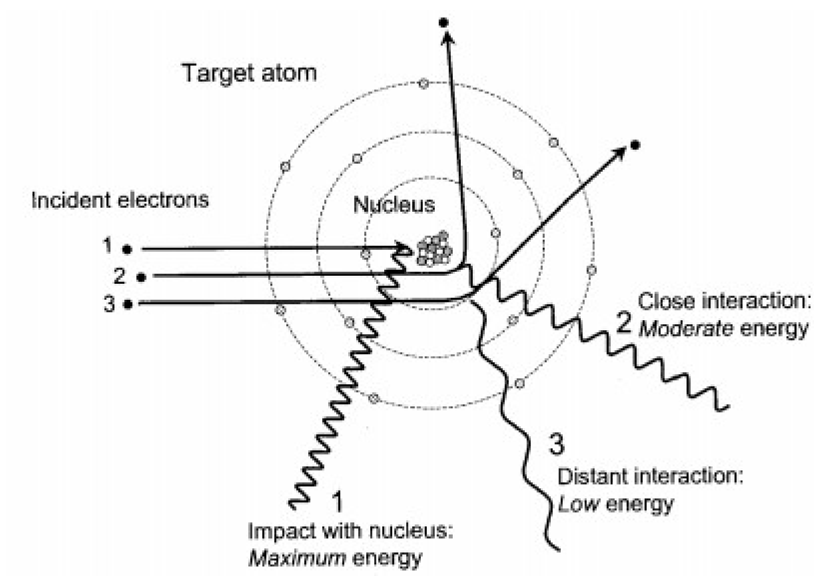


Figure (2.2): shows Bremsstrahlung radiation arises from energetic electron interactions within atomic nucleus of the target material(JERROLD T et al, 2002.) .

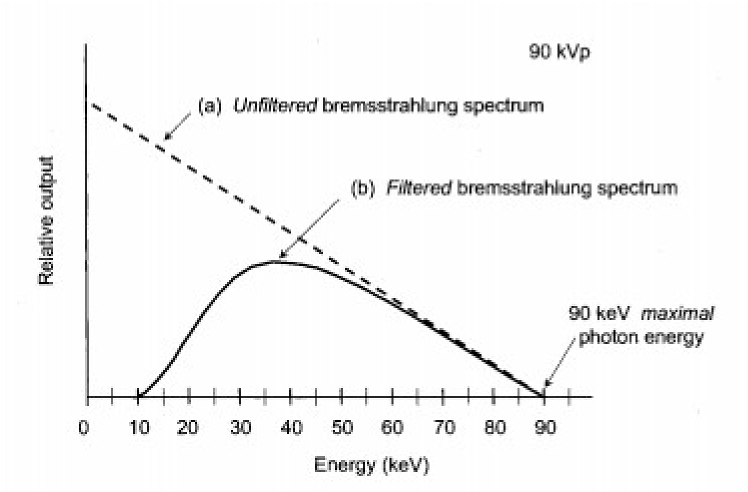


FIGURE (2.3): The bremsstrahlung energy distribution for 90kVp acceleration potential (JERROLD T et al, 2002.) .

2.1.2 Characteristic X-Ray Spectrum:

Each electron in the target atom has a binding energy that depends on the shell in which it resides. Closest to the nucleus are two electrons in the K shell, which has the highest binding energy. The L shell, with eight electrons, has the next highest binding energy, and so forth. When the energy of an electron incident on the target exceeds the binding energy of an electron of a target atom, it is energetically possible for a collision interaction to eject the electron and ionize the atom. The unfilled shell is energetically unstable, and an outer shell electron with less binding energy will fill the vacancy. As this electron transitions to a lower energy state, the excess energy can be released as a characteristic x-ray photon with energy equal to the difference between the binding energies of the electron shells. (JERROLD T et al, 2002.)

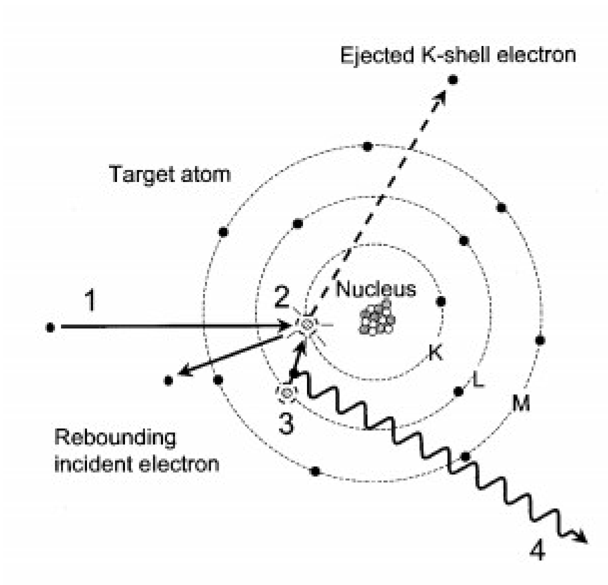


Figure (2.4): Generation of a characteristic x-ray(JERROLD T et al, 2002.).

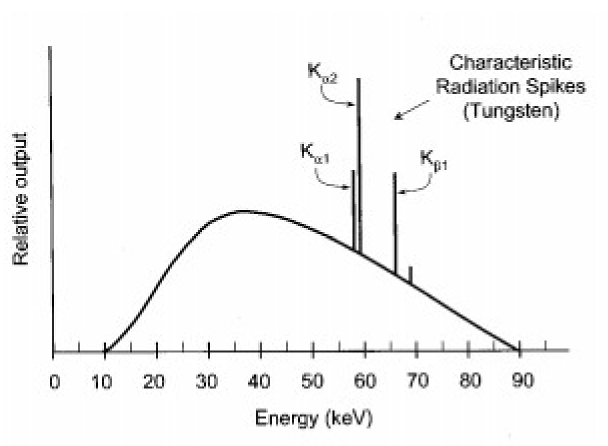


Figure (2.5): shows the filtered spectrum of bremsstrahlung and characteristic radiation (JERROLD T et al, 2002.) .

2.3 X- Ray interaction with mater:

X-rays have very short wavelengths, approximately 10−8 to 10−9 m. The higher the energy of an x-ray, the shorter is its wavelength. Consequently, low-energy x-rays tend to interact with whole atoms, which have diameters of approximately 10−9 to 10−10 m; moderate energy x-rays generally interact with electrons, and high-energy x-rays generally interact with nuclei X-rays interact at these various structural levels through five mechanisms: coherent scattering, Compton scattering, photoelectric effect, pair production, and photodisintegration. Two of these Compton scattering and photoelectric effect are of particular importance to diagnostic radiology. They are discussed in some detail here. (JERROLD T et al, 2002.)

2.3.1 Compton Scattering:

In Compton scattering, the incident x-ray interacts with an outer-shell electron and ejects it from the atom, there by ionizing the atom. The ejected electron is called a Compton electron. The x-ray continues in a different direction with less energy. The energy of the Compton-scattered x-ray is equal to the difference between the energy of the incident x-ray and the energy of the ejected electron. The energy of the ejected electron is equal to its binding energy plus the kinetic energy with which it leaves the atom ,During Compton scattering, most of the energy is divided between the scattered x-ray and the Compton electron . (JERROLD T et al, 2002.)

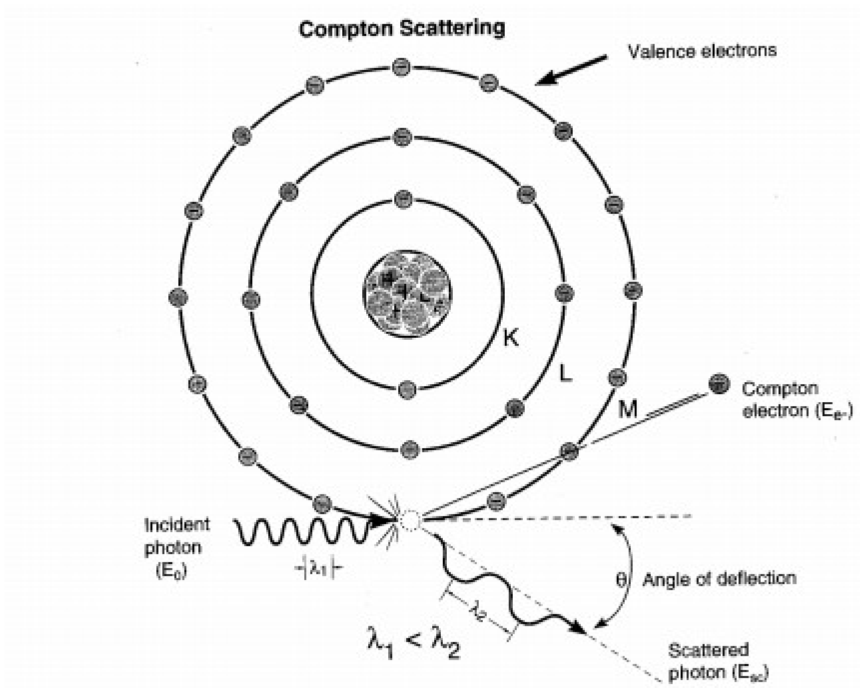


Figure (2.6): shows the Compton scattering (JERROLD T et al, 2002.)

2.3.2 Photoelectric Effect:

X-rays in the diagnostic range also undergo ionizing interactions with inner-shell electrons. The x-ray is not scattered, but it is totally absorbed. This process is called the photoelectric effect, The electron removed from the atom, called a photoelectron, escapes with kinetic energy equal to the difference between the energy of the incident x-ray and the binding energy of the electron A photoelectric interaction cannot occur unless the incident x-ray has energy equal to or greater than the electron binding energy.

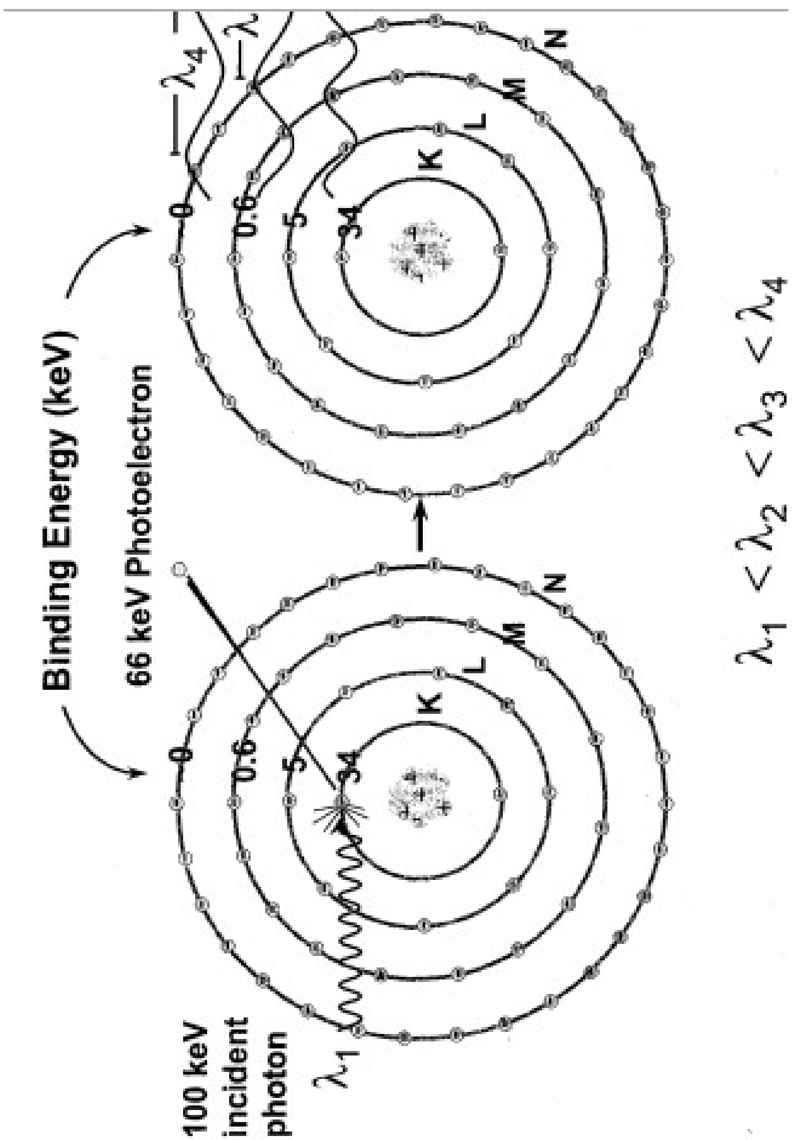


Figure (2.7): shows photoelectric effect (JERROLD T et al, 2002.)

2.4 Collimations:

Collimation restricts the useful x-ray beam to that part of the body to be imaged and thereby spares adjacent tissue from unnecessary radiation exposure. Collimators take many different forms. Adjustable light-locating collimators are the most frequently used collimating devices. Collimation also reduces scatter radiation and thus improves image contrast.(Bushong , 2013).

2.4.1 Beam Restrictors:

Three types of beam-restricting devices are used: the aperture diaphragm, cones or cylinders, and the variable-aperture collimator. (Bushong, 2013).

2.4.1.1 Aperture Diaphragm:

An aperture is the simplest of all beam-restricting devices. It is basically a lead or lead lined metal diaphragm that is attached to the x-ray tube head. The opening in the diaphragm usually is designed to cover just less than the size of the image receptor used The most familiar clinical example of aperture diaphragms may be radiographic imaging systems for trauma. The typical trauma system has a fixed source to-image receptor distance (SID) and is equipped with diaphragms designed to accommodate film sizes of 13 × 18 cm, 20 × 25 cm, and 25 × 30 cm.

Radiographic imaging systems for trauma can be positioned to image all parts of the body. (Bushong, 2013).

2.4.1.2 Cones and Cylinders:

Radiographic extension cones and cylinders are considered modifications of the aperture diaphragm. In both, an extended metal structure restricts the useful beam to the required size. The position and size of the distal end act as an aperture and determine field size. In contrast to the beam produced by an aperture diaphragm, the useful beam produced by an extension cone or cylinder is usually circular. Both of these beam restrictors are routinely called cones even though the most commonly used type is actually a cylinder, one difficulty with using cones is alignment. If the x-ray source, cone, and image receptor are not aligned on the same axis, one side of the radiograph may not be exposed because the edge of the cone may interfere with the x-ray beam. Such interference is called cone cutting. At one time, cones were used extensively in radiographic imaging. Today, they are reserved primarily for examinations of selected areas. (Bushong, 2013).

2.4.1.3 Variable Aperture Collimator:

The light-localizing variable-aperture collimator is the most commonly used beam-restricting device in radiography. (Bushong, 2013).

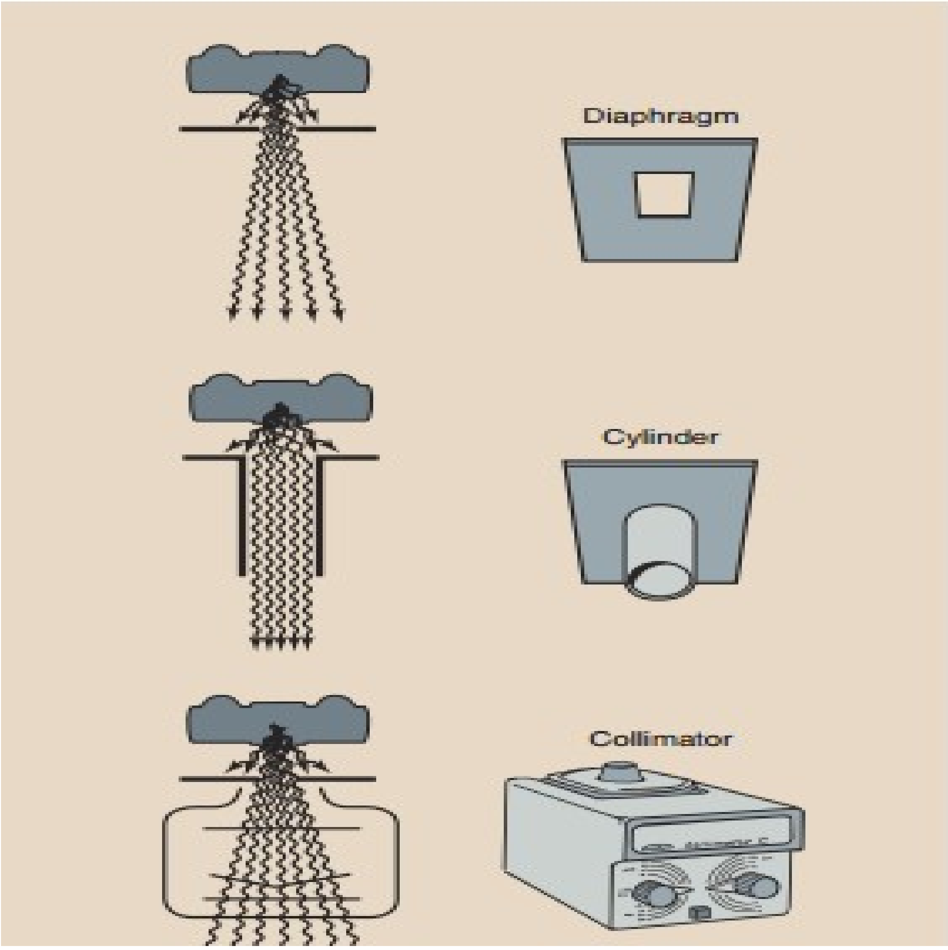


Figure (2.8): shows 3 types of Beam Restrictors.(Bushong , 2013)

2.4.1.4 Collimation reduces the patient radiation dose and improves contrast resolution:

Not all x-rays are emitted precisely from the focal spot of the x-ray tube .Some x-rays are produced when projectile electrons stray and interact at positions on the anode other than the focal spot. Such radiation, which is called off-focus radiation, increases image blur, To control off-focus radiation, a first-stage entrance shuttering device that has multiple collimator blades protrudes from the top of the collimator into the x-ray tube housing. The leaves of the second-stage collimator shutter are usually made of lead that is at least 3 mm thick. They work in pairs and are independently controlled, thereby allowing for both rectangular and square fields, (bushong, 2013).Light localization in a typical variable-aperture collimator is accomplished with a small lamp and mirror. The mirror must be far enough on the x-ray tube side of the collimator leaves to project a sufficiently sharp light pattern through the collimator leaves when the lamp is on. The collimator lamp and the mirror must be adjusted so that the projected light field coincides with the x-ray beam. If the light field and the x-ray beam do not coincide, the lamp or the mirror must be adjusted. Such coincidence checking is a necessary evaluation of any quality control program. (Bushong, 2013).

2.5 QUALITY ASSURANCE:

Quality assurance means the planned and systematic actions that provide adequate Confidence that a diagnostic x-ray facility will produce consistently high quality images with Minimum exposure of the patients and healing arts personnel. The determination of what Constitutes high quality will be made by the facility producing the images. Quality assurance actions include both “quality control” techniques and “quality administration” procedures. Quality control techniques" are those techniques used in the monitoring (or testing) and Maintenance of the components of an x-ray system. The quality control techniques thus are concerned directly with the equipment. Quality administration procedures" are those management actions intended to guarantee that monitoring techniques are properly performed and evaluated and that necessary corrective measures are taken in response to monitoring results. These procedures provide the organizational framework for the quality assurance program. (Bushong, 2013).

2.5.1 THE QUALITY CONTROL PROCESS

2.5.1.1 Equipment Selection:

Quality begins with proper equipment selection. The diagnostic medical physicist, having been educated in the administrative, technical, and clinical aspects of equipment performance, Equipment must be appropriate in terms of its ability to deliver the quality necessary for a particular imaging task at a cost to both patient and hospital (or clinic) that is reasonable in terms of dose, dollars, and downtime. Prior to the request for a quotation on any imaging device, the medical physicist should compile a set of performance specifications upon which such a quote should be based. These bid specifications will form the basis for acceptance tests to be performed upon installation. As such, they will necessarily be detailed and should be as specific as possible in terms of the tests to be performed and the results expected. The performance levels stated in these specifications should reflect the anticipated needs for successful utilization of the procedure room as envisioned by the radiologists and technologists. Specifications should include requirements for , Generators, X-ray tube assemblies , Patient support assemblies , Image receptors or video chains , Display systems , Archival systems , Gantry configuration and Peripheral devices . (S,Chairmen et al,2002)

2.5.1.2 Acceptance Testing:

Once an appropriate system has been selected and installed, it is the diagnostic medical physicist's responsibility to assure that the equipment functions safely, according to all published claims made by the vendor, and as agreed to in any contract-related documents created during the selection process (including the bid specifications). Documentation of the system performance during the warranty period may become a critical issue and hence must be carefully maintained. (S, Chairmen et al, 2002)

2.5.1.3 quality control:

Following successful installation and acceptance, equipment must be monitored on an ongoing basis to ensure continued, reliable performance. This ongoing, periodic evaluation procedure is quality control (QC). The purpose of QC testing is to detect changes that may result in a clinically significant degradation in image quality or a significant increase in radiation exposure. (S, Chairmen et al, 2002)

2.5.1.4 Documentation;

Test results should be recorded in a database for analysis.2 Performance comparisons should be made routinely to assure constancy in the performance of each device as well as consistency between devices (S, Chairmen et al, 2002)

2.5.1.5 Staffing Considerations:

Routine (daily, weekly, and monthly) QC testing should be performed by a technologist and reviewed periodically by a diagnostic medical physicist. This testing is normally performed with simple QC instruments and phantoms. Tests with quarterly to annual frequencies may be performed either by a diagnostic medical physicist or a well-trained QC technologist working under the supervision of a medical physicist, depending upon the complexity of the test and the competency of the technologist. Responsibility for training of all personnel utilized for quality control and analysis of all results is the responsibility of the diagnostic medical physicist. Recommendations for physics staffing are given in the AAPM Report No. 33(S, Chairmen et al, 2002)

2.5.2 QC deals with instrumentation and equipment:

Quality control begins with the x-ray imaging systems used to produce the image and continues with the routine evaluation of image-processing facilities. QC concludes with a dedicated analysis of each image to identify deficiencies and artifacts and to minimize reexaminations. Each new piece of radiologic equipment, whether it is x-ray producing or image processing, should be acceptance tested before it is applied clinically. The acceptance test must be done by someone other than the manufacturer’s representative because it is designed to show that the equipment is performing within the manufacturer’s specifications and is producing an acceptable patient radiation dose. With use, the performance characteristics of all such items of equipment change and may deteriorate. Consequently, periodic monitoring of equipment performance is required. On most systems, annual monitoring is satisfactory unless a major component such as an x-ray tube has been replaced. When periodic monitoring shows that equipment is not performing as was intended, maintenance or repair is necessary. Preventive maintenance usually makes repair unnecessary. (Bushong, 2013).

2.5.3 Light/X-Ray Field Congruence of Collimators:

The x-ray field must coincide with the light field of the variable-aperture light-localizing collimator. If these fields are misaligned, the intended anatomy will miss and unintended anatomy irradiated. Adequate collimation can be confirmed with any of a number of test tools designed for that purpose. (Bushong, 2013).

2.5.4 Methods of test:

4 each 1/16in x1in x 3in (1.5mm x 2.5cm x 7.5cm steel strips or 9 pennies or commercial alignment test tool. 1 loaded 14in x 17in (35m x 43m) film cassette for the initial test and 8in x 10in (20cm x 25cm)for subsequent routine tests. and Common tape measure. Test Procedure - Routine Test: Position the x-ray source over the table top so that the distance from source to tabletop is 40in (l00 cm). Inspect the collimator. Place the loaded 8inx10in cassette on the tabletop. Position the 9 pennies, center the cassette, and adjust the collimator so that the light field is as shown below. Make the exposure to give a medium density (about1.0typ.ex.60kVp, 5mAs). Develop and inspect the film. Save the film for comparison in future tests.(M. Siedband,1977)

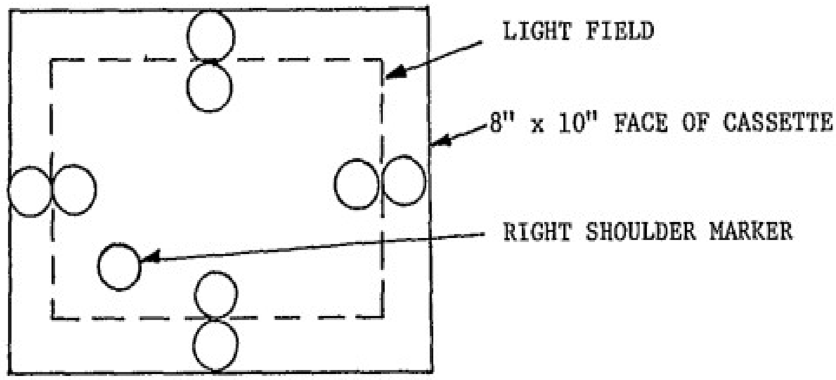
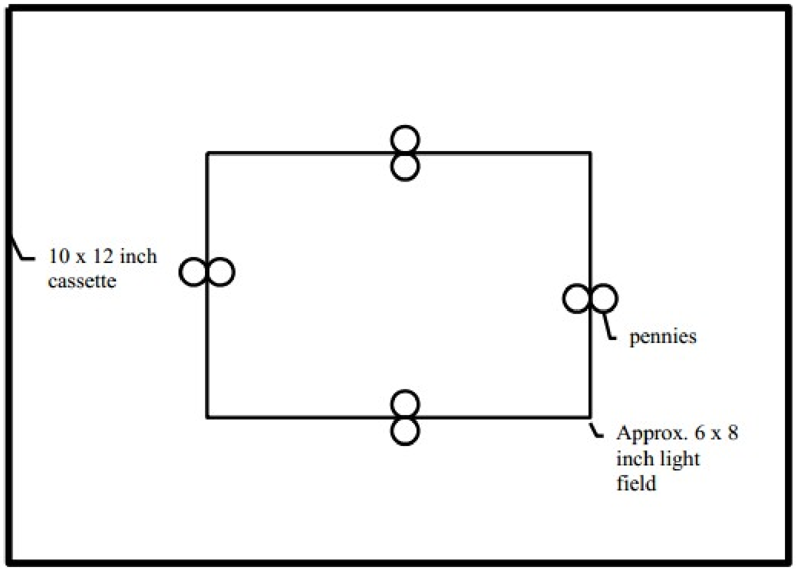


Figure (2.9): showstheArrangement ofexperimental set up for exposure. (M. Siedband, 1977)

Other test methods:

Place a 10 x 12 inch (24 x 30 cm) loaded cassette in the Bucky and set the SID at 40 inches (100 cm). If possible, adjust the field size to 6 x 8 inches (15 x 20 cm). The field must be smaller than the film. If your system is not equipped with a variable collimator, attach a beam limiting device (BLD) that provides a field size smaller than the cassette. Place the coins as shown in Figure 2. 4. Expose (65 kVp,4mAs) and develop the film. If field edges are not well defined, adjust techniques accordingly and repeat this step. (John Winston,2001)



Figure(2.10): shows the Arrangement of experimental set up for exposure. (John Winston, 2001)

Other test methods: A loaded cassette, a measuring tape and a bubble level were utilized in the field size and alignment testing.

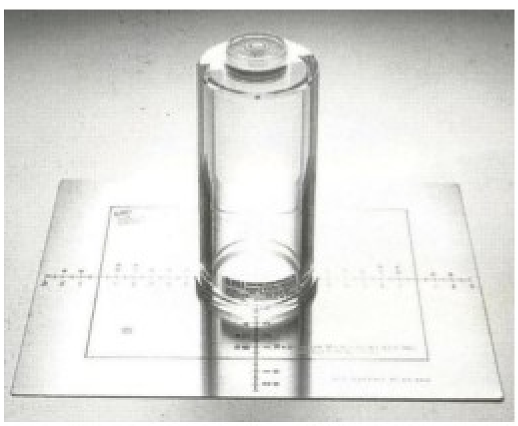


Figure (2.11): Collimator and Alignment Test **shows the Beam Tool** **(**N.BAkaagerger et al, (2015))

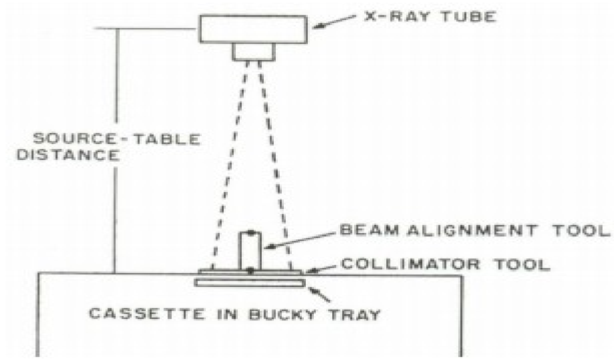


Figure (2.12): shows Placement of Collimator and Beam Alignment Test Tools for proper exposure (N.BAkaagerger et al, (2015))

2.5.5 Misalignment must not exceed 2% of the SID:

Most systems today are equipped with positive beam–limiting (PBL) collimators. These devices are automatic collimators that sense the size of the image receptor and adjust the collimating shutters to that size. Because different sizes of image receptors must be accommodated, the PBL function must be evaluated for all possible receptor sizes. With a PBL collimator, the x-ray beam must not be larger than the image receptor except in the override mode. Distance and centering indicators must be accurate to within 2% and 1% of the source-to-image receptor distance (SID). (Bushong, 2013).

2.6 previous studies:

Survey on quality control measurement for diagnostic imaging equipment in Paraiba brazil (2008and 2009) by Mendes Ac et al, Evaluation of medical X-ray machines in Paraiba state radiology centers between 2008 and 2009 To evaluate the light and radiation fields congruence and radiation beam alignment in medical X-ray equipment in Paraiba state radiology centers by means of two quality control tests. A loaded cassette, a measuring tape and a bubble level were utilized in the field size and alignment testing. The evaluation of collimation systems accuracy and X-ray beam alignment was undertaken during health inspections performed in radiology centers between 2008 and 2009. Survey was carried out the percentage of problematic X-ray machines decreased between 2008 and 2009; notwithstanding no quality assurance program has been observed in Paraiba state radiology centers.Other study studies on the status of light beam diaphragms in *calabar, effect and* implications on radiation protection by*N. O. Egbe, et al, (2003),* to check the beam alignment and collimator accuracy of x-ray equipment in diagnostic centers in Calabar, using a quality assurance test method, Results showed an increase in misalignment of the x-ray field and light field with an increase in the light field. The greatest misalignments were 7.9% and 5.6% along the cassette and across the cassette respectively. On the other hand, the least misalignments across and along the cassettes were 0.3% and 1.1% respectively. This indicates an unacceptable status of LBDs in Calabar.And study by N.B Akaagerger et al, (2015), Evaluation of Quality Control Parameters of Half Value Layer, Beam Alignment and Collimator Test Tools on Diagnostic X-Ray Machines inMakurdi, Benue State-Nigeria for two major Hospitals designated A and B was carried out using Half-Value Layer, Beam alignment and Collimator test tools which were based on technical standards for radiological protection and quality control in medical diagnosis. The quality filtration of diagnostic X-ray in use at Hospitals A and B were checked using HVL at 80kVp, 70kVp and 60kVp while the collimator and beam alignment test were used to measure the degree of misalignment of the target points, The technique employed in determining HVL Awas based on reducing the intensity of the X-ray beam to half its original value using aluminum filters added at 2cm from the table and dose detected using DIAVOLT placed at 98cm from the centre of the X-ray tubes. The attenuation coefficient was obtained from a standard graph of Dose (μGy) verses Aluminum thickness (mm) where the slope gives the attenuation coefficient(μ)which was used in calculating HVL using the relationship $HVL = \ln 2 \div \mu$. The values of HVL calculated were then compared with minimum acceptable HVL values at the kVp setting as recommended by the International Commission on Radiological units and measurement. Also Hospital A was shown to have a misalignment of 0.2cm at 60kVp, 10mAs, 100cm FFD using a film size of 10x8cm2 while Hospital B had a misalignment of 0.6cm at 25mAs, 81cm FFD using a film size of 10x8cm2. The result of the work shows that the misalignment falls within the acceptable limit of 2.0cm as recommended by International Commission on Radiological Protection.

3. Chapter three

Materials and Methods

3.1 Materials:

3.1.1 Study sample:

This study include 7 diagnostic radiography department Khartoum state hospitals about the CR system x-ray machine , for 10 x-ray machines from difference manufactures .

3.1.2 Test tools:

9 coins, measuring tape and bubble levels

3.2 Methods:

3.2.1Technique:

the couch was leveled by the bubble level and an (35.4×35.4) cassette was placed on the x-ray couch under the light beam diaphragm, which was opened so as to visually observe the light field. The focus to film distance was maintained at 100 cm. The film was placed such that the light beam was focused at the center of the cassette. Nine (9) coins were positioned on the edge of the light depend on the field size open and one in the anode side for rotation showed in figure (3.1), This arrangement was then exposed to x-radiation using exposure factors of 50kV, 100mA ,0.5s and processed for images of the alignment of the light field to the x-ray field by computed radiography system. And the measurements were made with the meter rule. In the same exposure film measured the center of the film cassette holder and center of the x-ray field

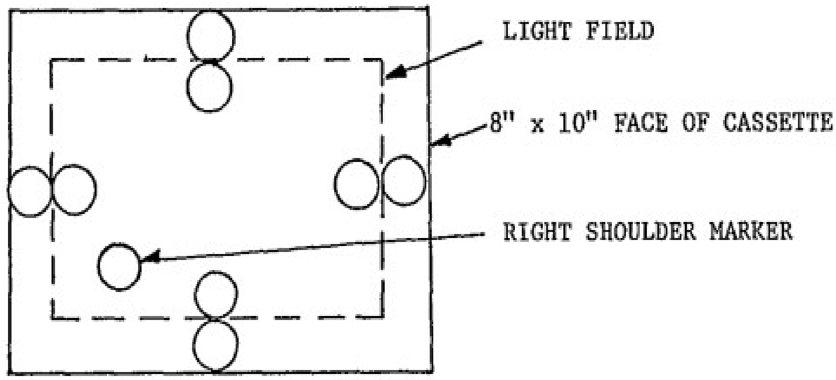


Figure (3.1) shows the test setup (M. Siedband, 1977)

3.2.2 Analysis:

Misalignments across the cassette (AC1 and AC2) and that along the cassette (AL1 and AL2) were added and recorded as total misalignment TOT AC and TOTAL, as follows: AC1 + AC2 = TOT AC (total misalignment across the cassette) AL1 + AL2 = TOT AL (total misalignment along the cassette) To determine the % misalignment of light versus x-ray field along and across the cassette, the total misalignment was divided by the focus to film distance (100 cm) and multiplied by 100 and in the same film measured the percentage of the center misalignment of the film in the cassette holder and center of the x-ray field at the SID 100 as shown

$\frac{TOT\ AC}{100} \times 100$ = % misalignment of light vs. x-ray field across cassette

$\frac{TOT\ AL}{100}$ × 100 = % misalignment of light vs. x-ray field along cassette

(CtrMis / 100") 100 = % misalignment of the center of the film in the cassette holder and the center of the x-ray field at an SID of 40 inches.

If either of the above is greater than 2%, corrective action is necessary.

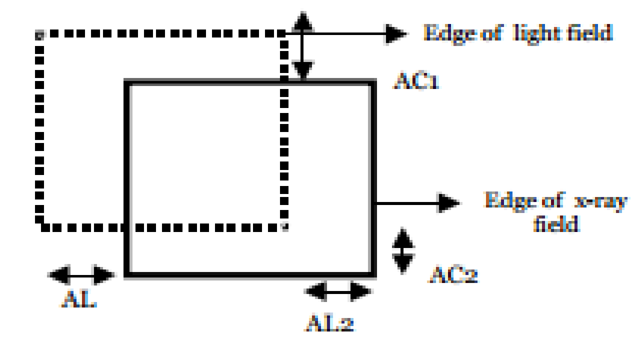
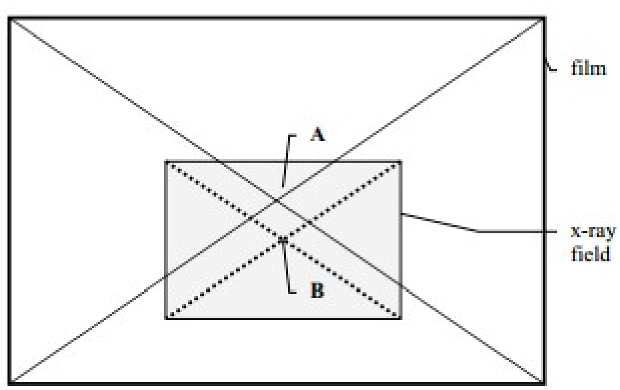


Figure (3.2) Determining the Total Misalignment of the Light Field and the X-ray Field.(*N. O. Egbe, et al, (2003))*



Figure(3.3)Determining Alignment of X-ray Field to Cassette Holder. . (John Winston, 2001)

4. Chapter Four

4-Result

This study has been done in the diagnostic department at the 7 hospitals on Khartoum state, for 10 x-ray machines appears different measurement of alignment of x-ray field to cassette holder under the limits, also show the distribution of the field of the x-ray and light beam correct adjust for good measurement another collect the no of manufactures and date to compare between there.

Table (4.1): Distributions of machines according to manufactures date.

Date of manufacture	Number of machine
2000-2009	5
2010-2015	5

Figure (4.1): Distributionof machines according to manufactures date.

Manufacture company	Number of machine
Toshiba	5
Shimazo	2
Philips	1
Unknown	2

Table (4.2): Distribution according to Manufactures

Figure (4.2): Distribution according to Manufactures.

Table (4.3): Total misalignments measurements

No of equipment	Measurements of misalignment		
1	Directions	Measurement (cm)	Total (cm)
	AL1 AL2	3.6 0.7	4.3
	AC1 AC2	0.1 0.4	0.5
2	AL1 AL2	0.2 0.3	0.6
	AC1 AC2	0.4 0.4	0.8
3	AL1 AL2	0.3 1.0	1.3
	AC1 AC2	0.5 1.0	1.5
4	AL1 AL2	1.2 0.9	2.1
	AC1 AC2	0.6 0.3	0.9
5	AL1 AL2	1.2 1.0	2.2
	AC1 AC2	0.4 0.4	0.8
6	AL1 AL2	0.5 0.8	1.3
	AC1 AC2	0.5 0.4	0.9
7	AL1 AL2	0.4 0.3	0.7
	AC1 AC2	1.0 0.4	1.4
8	AL1 AL2	0.2 0.1	0.3
	AC1 AC2	0.3 0.2	0.5
9	AL1 AL2	0.3 0.3	0.6
	AC1 AC2	0.3 0.1	0.4
10	AL1 AL2	0.5 0.2	0.7

AL1 + AL2: Total along cassette misalignment in cm

AC1 + AC2: Total across cassette misalignment in cm

Figure (4.3): Total misalignments measurements for a long cassette.

Figure (4.4): Total misalignments measurements for across cassette.

Table (4.4): Total measurements of Alignment of X- Ray field to Cassette Holder.

No of machine	Alignment of central ray (cm)
1	1.3
2	0.9
3	1.1
4	1.2
5	0.8
6	0.9
7	0.4
8	1.1
9	1.5
10	0.4

- All these measurement under the limits that is 2cm.

Figure (4.5): Total measurements of Alignment of X- Ray field to Cassette Holder.

Table (4.5):show collimators accuracy

Calcifications	Number of apparatus	Percentage
Acceptance	7	70%
Un acceptance	3	30%
Total	10	100%

Figure (4.5): shows the collimators accuracy

5. Chapter Five

5.1 DISSCATION:

This study has been conducted at diagnostic department in Khartoum state and covered 7 hospitals; the main objective was to assessment of the collimator accuracy in x-ray machines conducting QC tests. The measurements of QC tests were performed in accordance to some international standards which are CRCPD's, AAPM.

This study showed there is high percentage of light field and x-radiation field congruency about 70% from the study group, and only 30%(4.3,2.1,2.2,)cm felled out the acceptance limit that was 2% from SID that is 2 cm ,This implies that poor congruency between light fields to radiation field that showed in table and figure (4.5)(4.5) respectively ,compare our study with previous study by (N.B Akaagerger et al, (2015)) which carry out your result the Qc is applied because the Qc was done after maintenance of machine ,our result is better may be due to recent installment of the machine and compare with other studies by (*N. O. Egbe, et al , (2003))* result showed that the least misalignments across and along the cassettes were 0.3% and 1.1% respectively. This indicates an unacceptable status of LBDs in Calabar due to geometric cut-off, and study by (Mendes A c et al, (2008and 2009)) also found that the collimation system accuracy test preformed demonstrated that the non complaint with light and radiation field congruence test were 22.1%&9.31% in 2008and 2009 respectively ,as regard the x-ray beam central ray alignment due to lack of qualified professionals for such programs and scarcity of qualified and experienced technical's for equipment maintenance .Also there is high alignment for perpendicularity between the x-radiation beam and cassette holder in all group of the study with sifting in the congruency of light field and x –ray field.

5.2 Conclusions:

A good x-ray equipment performance is not only a matter of complying with regulations, but also, and more importantly, a matter of permanent interest in improving the quality and efficiency at the radiology centers.

By testing the light and radiation fields' congruence and the X-ray beam central ray perpendicularity in machine at Khartoum state hospitals in radiology department our result was carried out there is high percentage of light field and x-ray field congruence about 70% and lower percentage of misalignment 30% .

This implies that, the light-radiation field congruency and x-ray beam central ray were in alignment in Khartoum state.

5.3 Recommendations:

- The implementation of quality assurance programs at the institutions operating diagnostic x-ray machines is proposed, with periodical evaluation and adjustment of the machine by qualified professionals, with the purpose to of producing high quality images to allow correct diagnoses, with a reduction of the radiation dose delivered to the patients and involved professional exposed to radiation, as well as reducing the costs for the center ,as result of the reduction of imaging studies repetitions.
- The future study must be large case for QA programs and contains all QC tests for x-ray machines

- And there is need for an improved maintenance culture among radiography equipment users.

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Appendix

Figure (A) shows X-ray machine

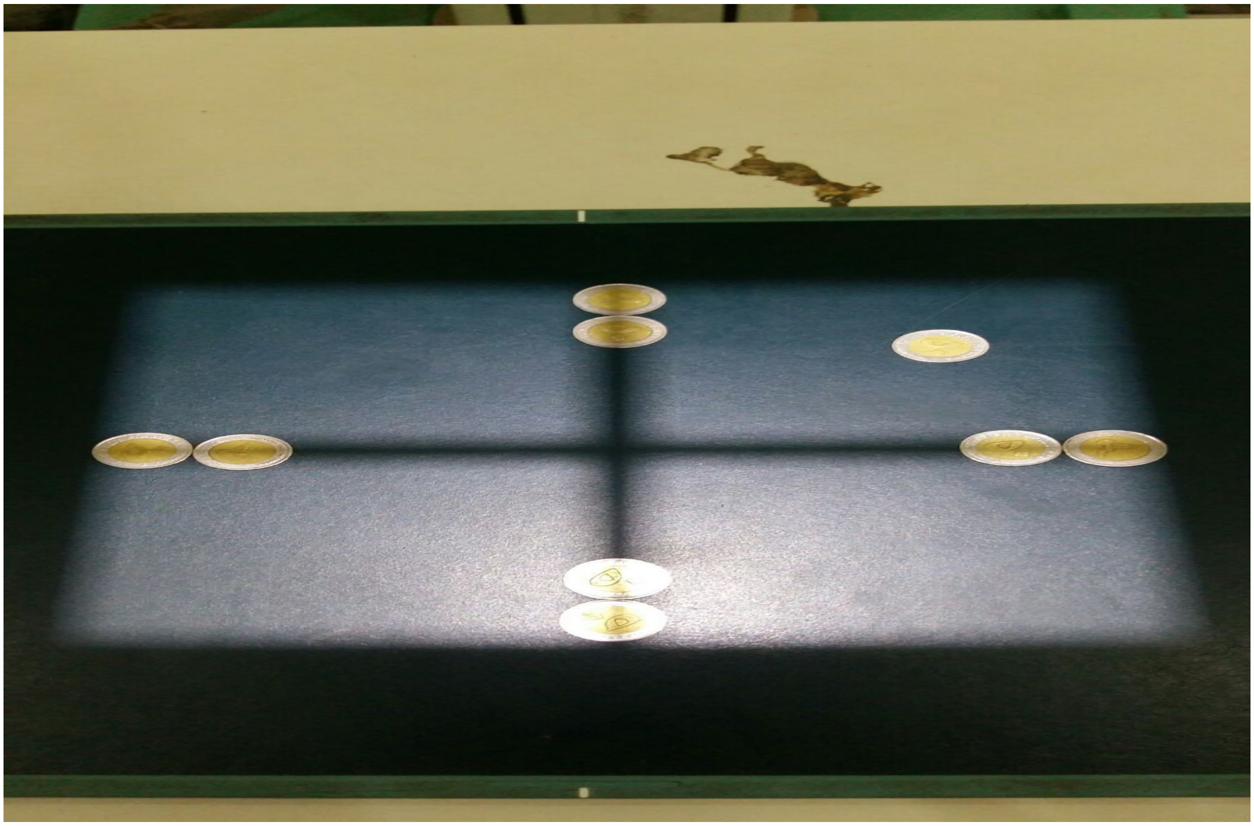

Figure (B) shows The Test setup

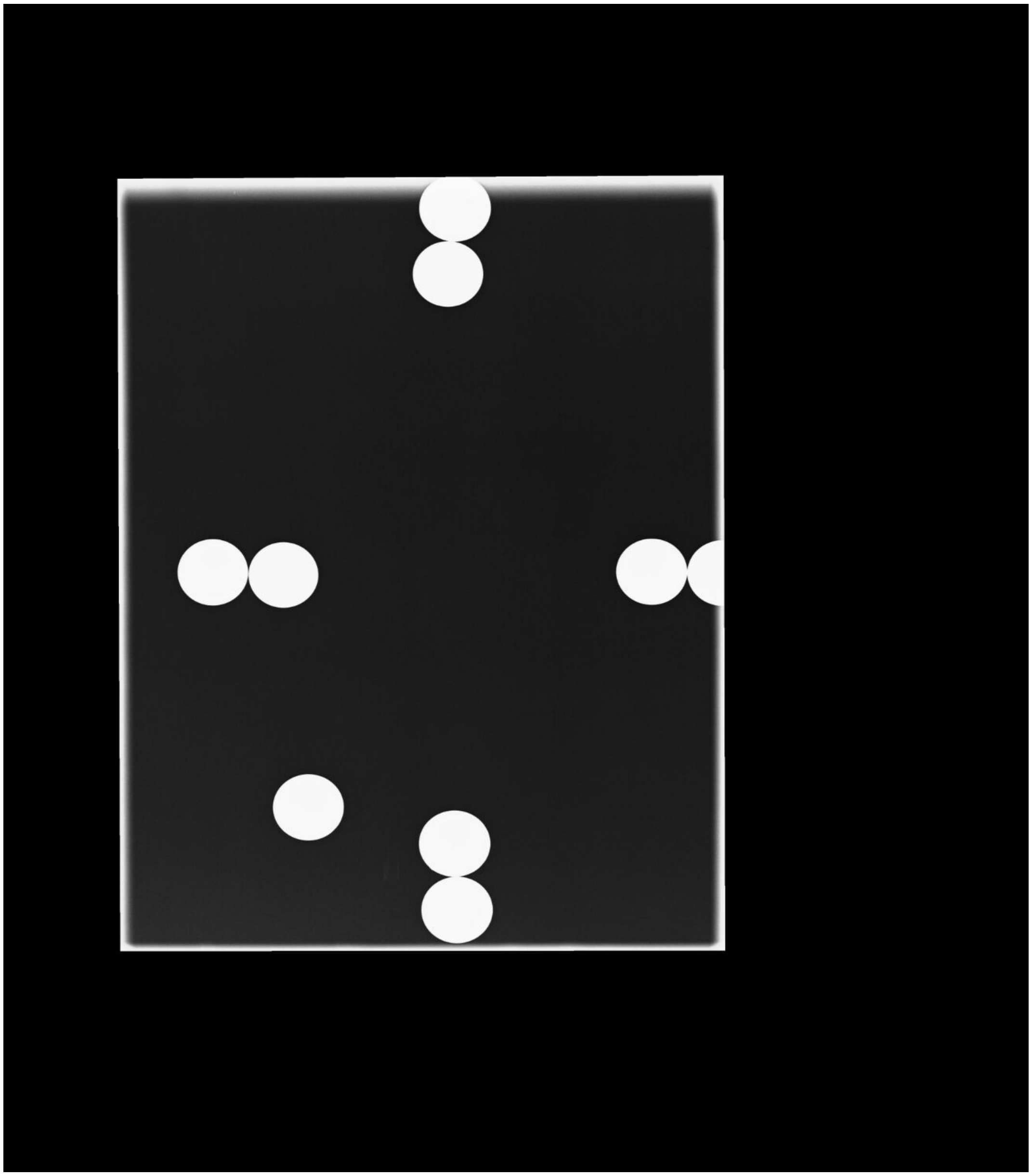

Figure (C) shows the film of Misalignment machine

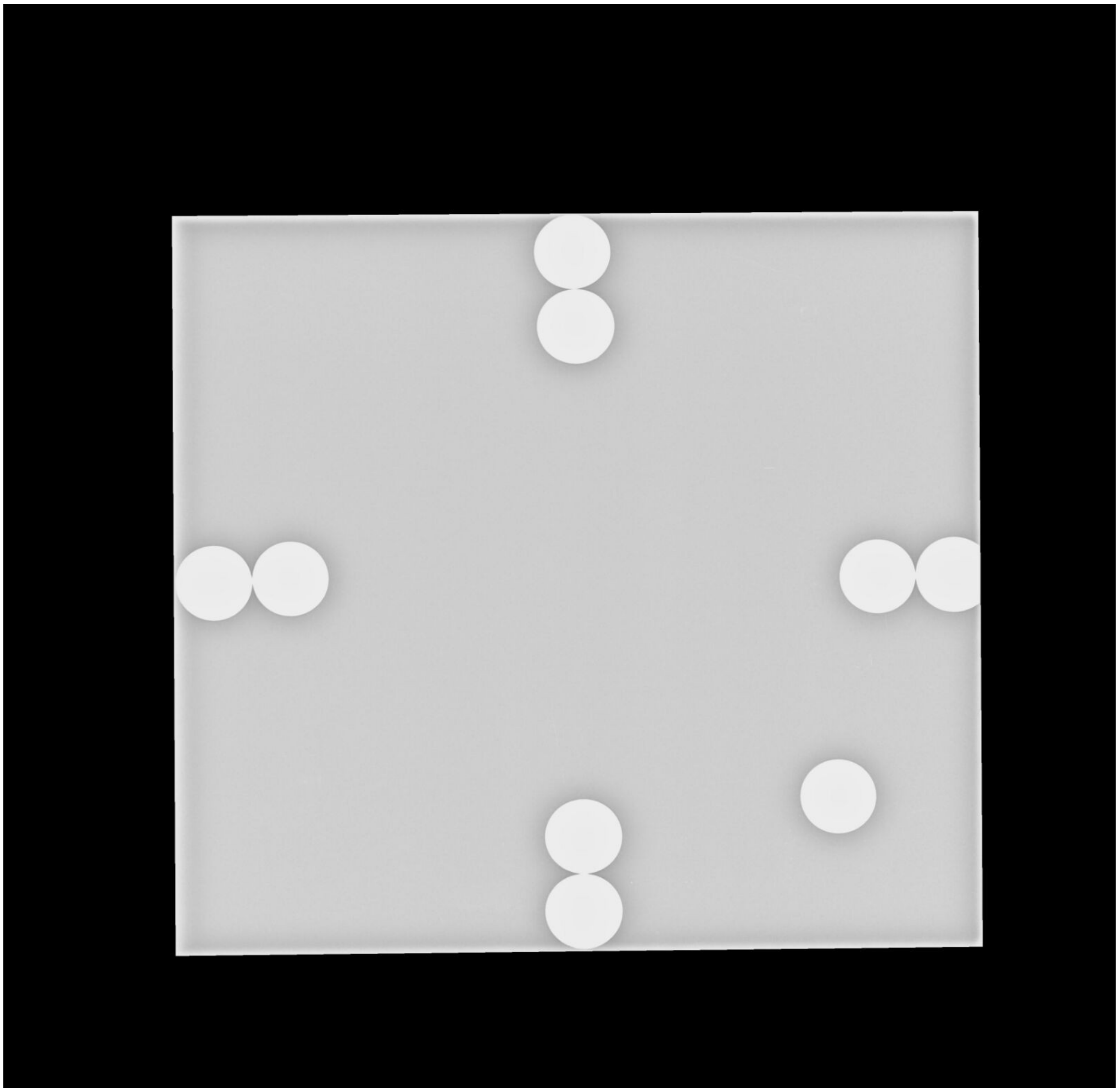

Figure (D) shows film of Alignment machine