Sudan University of Science and Technology

College of Graduate Studies

Assessment of Grid Alignment for X-Ray Units in Khartoum State.

تقويم محازاة الشبكة لوحدات الأشعة بولاية الخرطوم.

Thesis submitted for partial fulfillment for the requirements of Master degree in Medical Physics

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الآية

قال تعالى:

" قُلْ هُوَ اللَّهُ أَحَدٌ * اللَّهُ الصَّمَدُ * لَمْ يَلِدْ وَلَمْ يُولَدْ * وَلَمْ يَكُنْ لَهُ كُفُوًا أَحَدٌ "

صدق الله العظيم

سورة الإخلاص من الأية 1 إلى 4

Dedication

To my lovely parents, husband, daughters and my mother that candle that burn to light other life.

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

To my friends and my colleagues.

To my medical physics family.

I dedicate this work to you

Acknowledgments

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

Then I would like to express my sincere gratitude to my supervisor **Dr: Hussein Ahmad Hassan** for his suggestion, patient, guidance, encouragement, cooperation and supervision of this work.

I am also so grateful to every person helped me in gathering different information, collecting data and guiding me from time to time in making this project.

Thank you all

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List of abbreviations

QA: Quality Assurance.

QC: Quality Control.

AAPM: American Association of Physicist in Medicine.

OD: Optical Density.

h: hole.

STD: Source to Table top Distance.

SID: Source Image Distance.

Abstract

This study was aimed to assessment of grid alignment for radiology departments in Khartoum state.

A total of 15 x-ray units in radiology departments in Khartoum state were tested by grid alignment test tool and the optical density for radiographic film was read by transition densitometer.

In this study the final result showed that the percentage of grid misalignment for x-ray machines (66.7%) greater than the grid alignment x-ray machines (33.3%). The final assessment of grid misalignment for radiology departments is most in Khartoum state.

This study recommended that all x-ray equipment's should be regularly checked using quality assurance tests.

الملخص

تهدف هذه الدراسة إلى تقييم مطابقة الحاجب لأقسام الأشعة في ولاية الخرطوم. وتم اختبار 15 وحدة أشعه سينية في بعض أقسم الأشعة في ولاية الخرطوم. كما تمت قراءه الكثافة الضوئية لأفلام الأشعة بواسطة جهاز قياس شدة الأشعة المارة عبره.

في هذه الدراسة أظهرت النتيجة النهائية أن نسبة عدم مواءمة الحاجب لأجهزة الأشعة السينية (66.7 ٪) أكبر من نسبة مطابقة الحاجب لأجهزة الأشعة السينية (33.3 ٪) . ووجد في التقييم النهائي أن معظم أقسام الأشعة في ولاية الخرطوم بها عدم مطابقة للحاجب.

هذه الدراسة توصي أنه يجب أن تكون هنالك فحص بانتظام لأجهزة الأشعة السينية باستخدام اختبارات ضمان الجودة.

Chapter one

1.1 . Introduction:-

When primary x-rays (x-rays leaving the tube) interact with the patient's body, x-rays are scattered from the patient in all directions. The scattering of the x-rays is due to an interaction called Compton scattering. This particular type of interaction results in a change in the x-ray direction and a reduction in x-ray energy. X-rays can be deflected in any direction but scattered photons tend to scatter in a more forward direction which means that they have a higher chance of reaching the image receptor. Scattered x-rays that reach the detector add no diagnostic value to the image. Rather, they cause the radiograph to appear gray and dull which reduces image contrast and thereby degrades image quality. To eliminate this problem, a device called a radiographic grid is used to control scatter radiation. The grid is designed to remove scatter radiation from the remnant beam (beam leaving the patient's body) and to transmit only the remnant photons which carry useful information to the image receptor, the grid is located between the patient and the image detector. Improper use of a grid however, can cause grid cutoff (which results in an underexposed radiograph) or grid artifacts such as grid lines.

One of the most common improper grid position is when the grid is off-center where partial grid cut-off occurs over the entire image receptor, this results in a uniform reduction of density across the entire film. This type of grid misalignment is harder to detect on radiographs (unlike grid artifacts such as grid lines) and can lead to increased patient dose and reduced image contrast. This is the reason why grid alignment tests should be performed as part of quality control in the radiography department (Bushong,2013).

The central ray of the x-ray beam should be aligned with the center of the image receptor, when placed in the Bucky, to prevent image cut-off. Most systems utilize a combination of both electromechanical détentes and alignment lights to indicate when the system is correctly aligned. Federal regulations11 currently require that the edges of the x-ray fields and corresponding image receptor edges agree to within ±2% of the SID. Tests should be performed at least annually or as often as necessary to maintain correct alignment. Older systems may require more frequent evaluation (Shepard et al,2002).

1.2 Problem of the study:-

Improper use of a grid can cause grid off-center where partial grid cut-off occurs (which results in an underexposed radiograph) or grid artifacts such as grid lines. Grid misalignment lead to increased patient dose and reduced image contrast. This is the reason why grid alignment tests should be performed as part of quality control in the radiography department.

1.3 Objectives:-

1.3.1 General Objective:-

Assessment of grid alignment in radiology departments (Khartoum state).

1.3.2 Specific objectives:-

-To insure the proper use of the grid in radiology departments.

- provide an effective means for reducing scatter.

-To achieve consistent and optimal image quality.

1.4 Layouts:-

This study composed of five chapters:

-Chapter one: introduction.

-Chapter two : theoretical background.

-Chapter three: materials and methods.

-Chapter four: results.

-Chapter five: discussion ,conclusion and recommendation.

Chapter two

Theoretical background

2.1. Literature review:

2.1.1.Quality Assurance Program:

An adequate diagnostic quality assurance (QA) program involves periodic checks of the components in a diagnostic x-ray imaging system. The optimum QA program for any individual facility will depend on a number of factors which include, but may not necessarily be limited to, items such as the type of procedures performed, type of equipment utilized, and patient workload (Chairman et al,1977).

It is a way of preventing mistakes or defects in manufactured products and avoiding problems when delivering solutions or services to customers; which ISO 9000 defines as "part of quality management focused on providing confidence that quality requirements will be fulfilled". This defect prevention in quality assurance differs subtly from defect detection and rejection in quality control, and has been referred to as a shift left as it focuses on quality earlier in the process (ISO 9000,2005).

QA is applied to physical products in pre-production to verify what will be made meets specifications and requirements, and during manufacturing production runs by validating lot samples meet specified quality controls. QA is also applied to software to verify that features and functionality meet business objectives, and that code is relatively bug free prior to shipping or releasing new software products and versions (Larry et al,2001).

2.1.1.1. 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, possesses a unique vantage point from which to assess appropriateness of imaging equipment. 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 (Chairman et al,1977).

2.1.1.2 . 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) (Chairman et al,1977).

2.1.2. 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(Chairman et al,1977).

2.1.2.1 .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(Chairman et al,1977).

2.1.2.2. QC instrumentation :-

The choice of instrumentation for performance of QC and acceptance testing depends upon the type of radiological equipment to be evaluated and the intended user. Instrumentation needs should be determined on a case-by-case basis (Shepard et al,2002).

2.1.3. Grid Alignment Test:-

Increased patient radiation dose and reduced image contrast can result from lateral decentering or tilting of a focused grid used in a Bucky apparatus. The Grid Alignment Test Tool is used to check whether a focused grid is aligned properly with the central ray and the center of the film cassette.

Ideally, the grid should absorb none of the primary radiation and 100% of the unwanted scattered radiation. In reality, a grid absorbs primary, secondary and scatter radiation — however, grids absorb much more scattered radiation than primary radiation. With focused grids, it is important to align the focal spot of the x-ray tube with the midpoint of the grid. Off centering will cause the primary radiation to be absorbed by the grid. This unacceptable condition is called grid cutoff (R.Tejeda,2009). The grid alignment test tool is a rectangular piece of lead encased in white plastic.

The tool measures 0.2 cm x 9.0 cm x 23 cm. There are a total of five holes on the grid Alignment Test Tool. The centers of the larger five holes are separated 2.5 cm from each other. Three smaller holes arranged in a triangular fashion will be used as “localization markers”. That illustrate in figure(2.1) (AAPM, 2005).

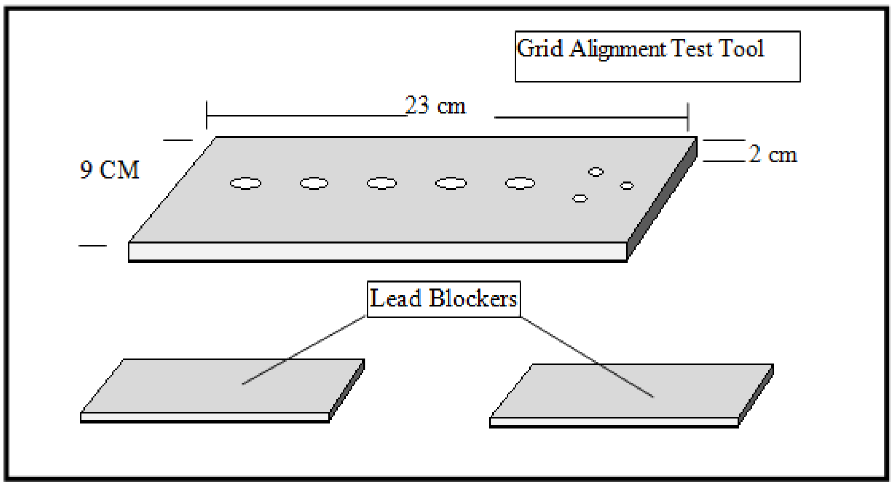


Figure (2.1) Grid alignment test tool.

The purpose of this research was to test the alignment of the radiographic grid in the Bucky mechanics with respect to the central ray of the x-ray tube. In this research, grid misalignment can be detected by analyzing the optical densities of the resultant dot images obtained using a grid alignment tool shown in Figure(2.2).

Figure(2.2) Grid alignment tool.

2.1.4. Radiographic Grids:-

Grids are placed between the patient and the X-ray film to reduce the scattered radiation (produced mainly by Compton effect) and thus improve image contrast. Scattered x-rays that reach the image receptor are part of the image-forming process; indeed, the x-rays that are scattered forward do contribute to the image. An extremely effective device for reducing the level of scatter radiation that reaches the image receptor is the radiographic grid, a carefully fabricated section of radiopaque material (grid strip) alternating with radiolucent material (interspace material). The grid is positioned between the patient and the image receptor (Bushong,2013).

Figure(2.3) Radiographic grid absorbed scattered x-rays radiation from the patient.

This technique for reducing the amount of scatter radiation that reaches the image receptor was first demonstrated in 1913 by Gustave Bucky. Over the years, Bucky’s grid has been improved by more precise manufacturing, but the basic principle has not changed. The grid is designed to transmit only x-rays whose direction is on a straight line from the x-ray tube target to the image receptor. Scatter radiation is absorbed in the grid material. Figure (2.3) is a schematic representation of how a grid “cleans up” scatter radiation. X-rays that exit the patient and strike the radiopaque grid strips are absorbed and do not reach the image receptor. For instance, a typical grid may have grid strips 50 μm wide that are separated by interspace material 350 μm wide. Consequently, even 12.5% of x-rays transmitted through the patient are absorbed (Bushong, 2013).

Primary beam x-rays incident on the interspace material are transmitted to the image receptor. Scattered x-rays incident on the interspace material may or may not be absorbed, depending on their angle of incidence and the physical characteristics of the grid. If the angle of a scattered x-ray is great enough to cause it to intersect a lead grid strip, it will be absorbed. If the angle is slight, the scattered x-ray will be transmitted similarly to a primary x-ray. Laboratory measurements show that high-quality grids can attenuate 80% to 90% of the scatter radiation. Such a grid is said to exhibit good "cleanup." (Bushong, 2013).

2.1.5. Grid Ratio:-

High-ratio grids are more effective in reducing scatter radiation than are low-ratio grids. This is because the angle of scatter allowed by high-ratio grids is less than that permitted by low-ratio grids (Figure2.4).

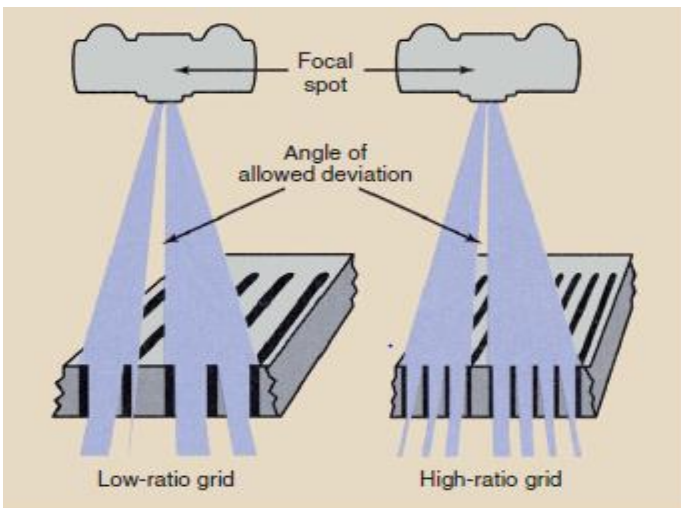


Figure (2.4) High-ratio grids are more effective than low ratio grids.

High-ratio grids increase the patient radiation dose. In general, grid ratios range from 5:1 to 16:1; higher-ratio grids are used most often in high-kVp radiography. An 8:1 to 10:1 grid is frequently used with general-purpose x-ray imaging systems. Whereas a 5:1 grid reduces approximately 85% of the scatter radiation, a 16:1 grid may reduce as much as 97%.(Bushong,2013).

2.1.6. Grid Strip:-

Theoretically, the grid strip should be infinitely thin and should have high absorption properties. These strips may be formed from several possible materials. Lead is most widely used because it is easy to shape and is relatively inexpensive. Its high atomic number and high mass density make lead the material of choice in the manufacture of grids. Tungsten, platinum, gold, and uranium all have been tried, but none has the overall desirable characteristics of lead (Bushong,2013).

2.1.7. Grid Performance:-

Perhaps the largest single factor responsible for poor radiographic image quality is scatter radiation. By removing scattered x-rays from the remnant beam, the radiographic grid removes the source of reduced contrast (Bushong,2013).

2.1.8. Grid Types:-

2.1.8.1 Parallel Grid:-

The simplest type of grid is the parallel grid, which is diagrammed in cross section in figure (2.5). In the parallel grid, all lead grid strips are parallel. This type of grid is the easiest to manufacture, but it has some properties that are clinically undesirable, namely grid cutoff**,** the undesirable absorption of primary x-rays by the grid (Bushong,2013).

The attenuation of primary x-rays becomes greater as the x-rays approach the edge of the image receptor. The lead strips in a (35 * 43)cm grid are 43 cm long. Across the 35-cm dimension, the signal intensity reaches a maximum along the center line of the image receptor and decreases toward the sides. Grid cutoff can be partial or complete. The term is derived from the fact that the primary x-rays are “cut off” from reaching the image receptor. Grid cutoff can occur with any type of grid if the grid is improperly positioned, but it is most common with parallel grids(Bushong,2013).

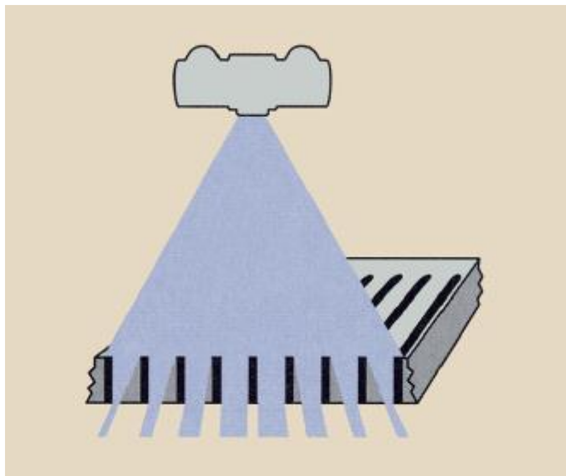


Figure (2.5) A parallel grid constructed from parallel grid strips.

2.1.8.2. Crossed Grid:-

Parallel grids clean up scatter radiation in only one direction along the axis of the grid. Crossed grids are designed to overcome this deficiency. Crossed grids have lead grid strips that run parallel to the long and short axes of the grid (Figure 2.6). They are usually fabricated by sandwiching two parallel grids together with their grid strips perpendicular to one another. They are not too difficult to manufacture and therefore are not excessively expensive. However, they have found restricted application in clinical radiology. (It is interesting to note that Bucky’s original grid was crossed.) (Bushong,2013).

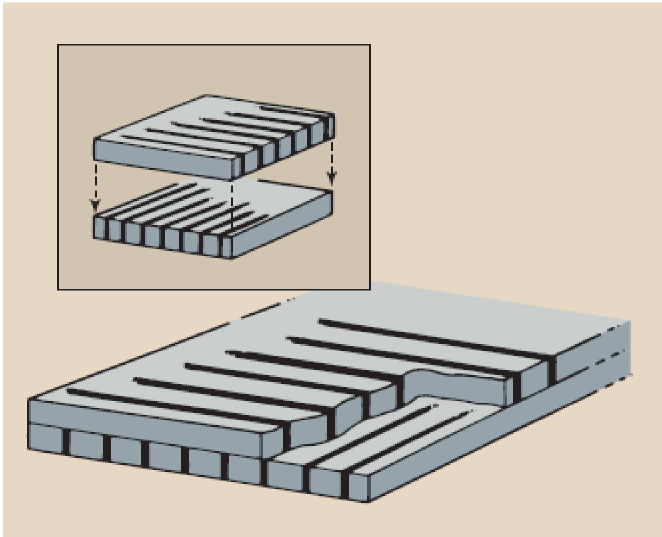


Figure (2.6) Crossed grids are fabricated by sandwiching two parallel grids together.

Crossed grids are much more efficient than parallel grids in cleaning up scatter radiation. In fact, a crossed grid has a higher contrast improvement factor than a parallel grid of twice the grid ratio. A 6:1 crossed grid will clean up more scatter radiation than a 12:1 parallel grid.

This advantage of the crossed grid increases as the operating kVP is increased. A crossed grid identified as having a grid ratio of 6:1 is constructed with two 6:1 parallel grids.

High-ratio grids have less positioning latitude than low-ratio grids. The main disadvantage of parallel and crossed grids is grid cutoff. Three serious disadvantages are associated with the use of crossed grids. First, positioning the grid is critical; the central ray of the x-ray beam must coincide with the center of the grid. Second, tilt-table techniques are possible only if the x-ray tube and the table are properly aligned. Finally, the exposure technique required is substantial and results in higher patient radiation dose. (Bushong,2013).

2.1.8.3 .Focused Grid:-

The focused grid is designed to minimize grid cutoff. The lead grid strips of a focused grid lie on the imaginary radial lines of a circle centered at the focal spot, so they coincide with the divergence of the x-ray beam. The x-ray tube target should be placed at the center of this imaginary circle when a focused grid is used (Figure 2.7). Focused grids are more difficult to manufacture than parallel grids. They are characterized by all of the properties of parallel grids except that when properly positioned, they exhibit no grid cutoff. Radiologic technologists must take care when positioning focused grids because of their geometric limitations(Bushong,2013).

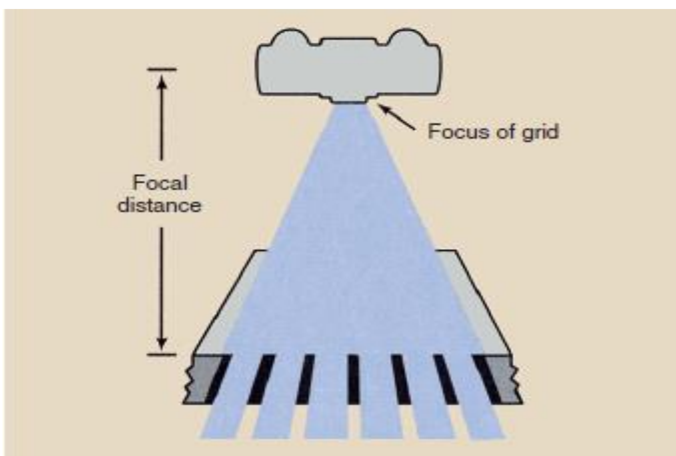


Figure (2.7) A focused grid.

High-ratio grids have less positioning latitude than low-ratio grids. Every focused grid is marked with its intended focal distance and the side of the grid that should face the x-ray tube. If radiographs are taken at distances other than those intended, grid cutoff occurs (Bushong ,2013).

2.1.8.4. Moving Grid:-

An obvious and annoying shortcoming of the grids previously discussed is that they can produce grid lines on the image. Grid lines are the images made when primary x-rays are absorbed within the grid strips. Even though the grid strips are very small, their image is still observable.

The presence of grid lines can be demonstrated simply by radiographing a grid. Usually, high-frequency grids present less obvious grid lines compared with low-frequency grids. This is not always the case, however, because the visibility of grid lines is directly related to the width of the grid strips. A major improvement in grid development occurred in 1920. Hollis E. Potter hit on a very simple idea: Move the grid while the x-ray exposure is being made. The grid lines disappear at little cost of increased radiographic technique. A device that does this is called a moving grid or a Potter-Bucky diaphragm ("Bucky" for short) (Bushong ,2013).

Focused grids usually are moving grids. They are placed in a holding mechanism that begins moving just before x-ray exposure and continues moving after the exposure ends. Two basic types of moving grid mechanisms are in use today: reciprocating and oscillating.

A reciprocating grid is a moving grid that is motor-driven back and forth several times during x-ray exposure, the total distance of drive is approximately 2 cm. An oscillating grid is positioned within a frame with a 2- to 3-cm tolerance on all sides between the frame and the grid. Delicate, spring like devices located in the four corners hold the grid centered within the frame. A powerful electromagnet pulls the grid to one side and releases it at the beginning of the exposure. Thereafter, the grid oscillates in a circular fashion around the grid frame, coming to rest after 20 to 30 seconds(Bushong ,2013).

Disadvantages of Moving Grids is require a bulky mechanism that is subject to failure. The distance between the patient and the image receptor is increased with moving grids because of this mechanism; this extra distance may create an unwanted increase in magnification and image blur. Moving grids can introduce motion into the cassette-holding device, which can result in additional image blur. Fortunately, the advantages of moving grids far outweigh the disadvantages. The types of motion blur discussed are for descriptive purposes only. The motion blur generated by moving grids that are functioning properly is undetectable. Moving grids are usually the technique of choice and therefore are used widely (Bushong ,2013).

2.1.9 .Grid problems:-

Most grids in diagnostic imaging are of the moving type. They are permanently mounted in the moving mechanism just below the tabletop or just behind the vertical chest board. To be effective, of course, the grid must move from side to side. If the grid is installed incorrectly and moves in the same direction as the grid strips, grid lines will appear on the radiograph (Figure2.8).

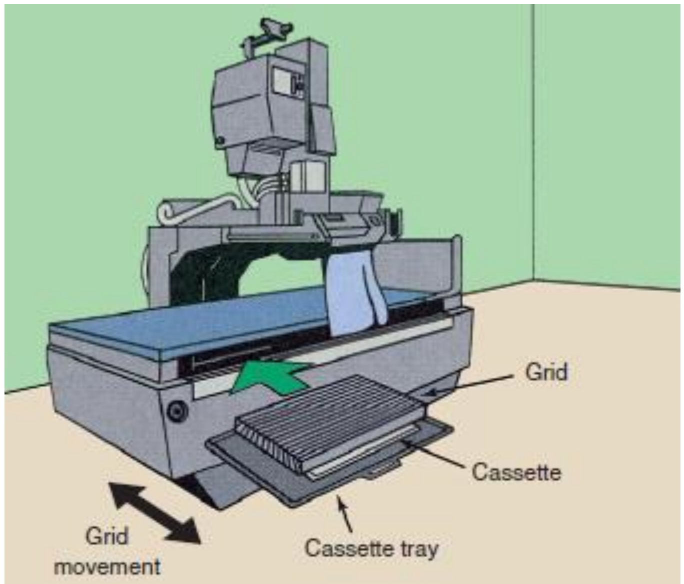


Figure (2.8) Proper installation of a moving grid.

The most frequent error in the use of grids is improper positioning. For the grid to function correctly, it must be precisely positioned relative to the x-ray tube target and to the central ray of the x-ray beam. Four situations characteristic of focused grids must be avoided table (2.1) Only the off-level grid is a problem with parallel and crossed grids (Bushong ,2013).

Table (2.1)shows focused-Grid Misalignment.

No	Type of grid misalignment	Result
1	Off level	Grid cutoff across image; underexposed, lite image
2	Off center	Grid cutoff across image; underexposed, lite image
3	Off focus	Grid cutoff toward edge of image
4	Upside down	Severe grid cutoff toward edge of image
5	Off center, Off focus	Grid cutoff on one side of image

2.1.9.1. Off-Level Grid:-

A properly functioning grid must lie in a plane perpendicular to the central ray of the x-ray beam in figure (2.9). The central ray x-ray beam is the x-ray that travels along the center of the useful x-ray beam.

Despite its name, an off-level grid in fact is usually produced with an improperly positioned x-ray tube and not an improperly positioned grid. However, this can occur when the grid tilts during horizontal beam radiography or during mobile radiography when the image receptor sinks into the patient's bed. If the central ray is incident on the grid at an angle, then all incident x-rays will be angled, and grid cutoff will occur across the entire radiographic image, resulting in lower OD or intensity at the digital image receptor(Bushong ,2013).

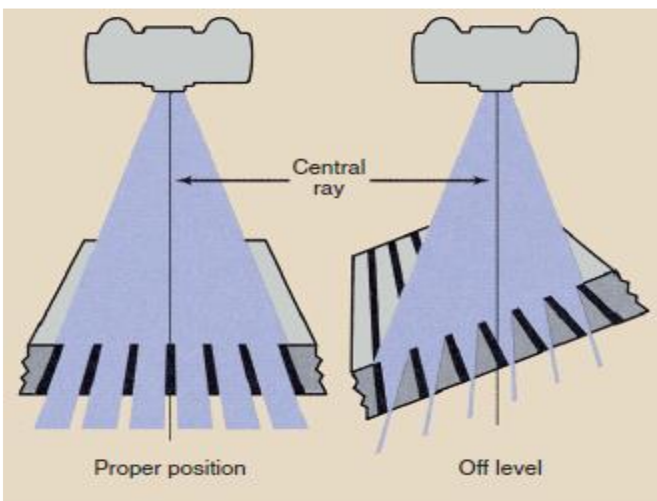


Figure (2.9) Off level grid, partial cutoff occurs over the entire image receptor.

2.1.9.2. Off-Center Grid:-

A grid can be perpendicular to the central ray of the x-ray beam and still produce grid cutoff if it is shifted laterally. This is a problem with focused grids, as shown in Figure (2.10), in which an off-center grid is shown with a properly positioned grid. The center of a focused grid must be positioned directly under the x-ray tube target, so the central ray of the x-ray beam passes through the centermost interspace of the grid. Any lateral shift results in grid cutoff across the entire radiograph, producing lower OD. This error in positioning is called lateral decentering**.** (Bushong,2013).

As with an off-level grid, an off-center grid is more a result of positioning the x-ray tube than the grid. In practice, it means that the radiologic technologist must carefully line up the center of the light-localized field with the center of the image receptor.

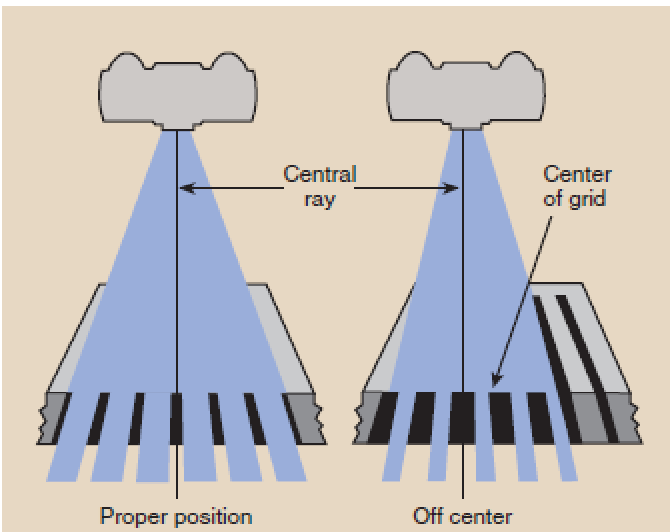


Figure (2.10) Off center grid, partial grid cutoff occurs over the entire image receptor.

2.1.9.3. Off-Focus Grid:-

A major problem with using a focused grid arises when radiographs are taken at SIDs unspecified for that grid. Figure (2.11)illustrates what happens when a focused grid is not used at the proper focal distance. The farther the grid is from the specified focal distance, the more severe will be the grid cutoff. Grid cutoff is not uniform across the image receptor but instead is more severe at the edges (Bushong,2013).

This condition is not usually a problem if all chest radiographs are taken at 180 cm SID and all table radiographs at 100 cm SID. Positioning the grid at the proper focal distance is more important with high-ratio grids; greater positioning latitude is possible with low ratio grids(Bushong ,2013).

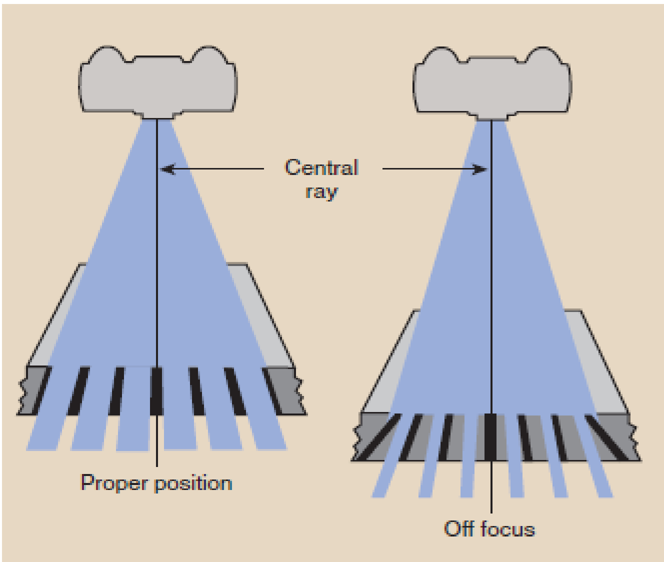


Figure (2.11) Off focused grid.

2.1.9.4.Upside-Down Grid:-

The explanation for an upside-down grid is obvious. It need occur only once, and it will be noticed immediately. A radiographic image taken with an upside-down focused grid shows severe grid cutoff on either side of the central ray in figure (2.12). Combined Off-Center, Off-Focus Grid. Perhaps the most common improper grid position occurs if the grid is both off center and off focus. Without proper attention, this can occur easily during mobile radiography. It is an easily recognized grid-positioning artifact because the result is uneven exposure. The resultant radiograph appears dark on one side and light on the other (Bushong , 2013).

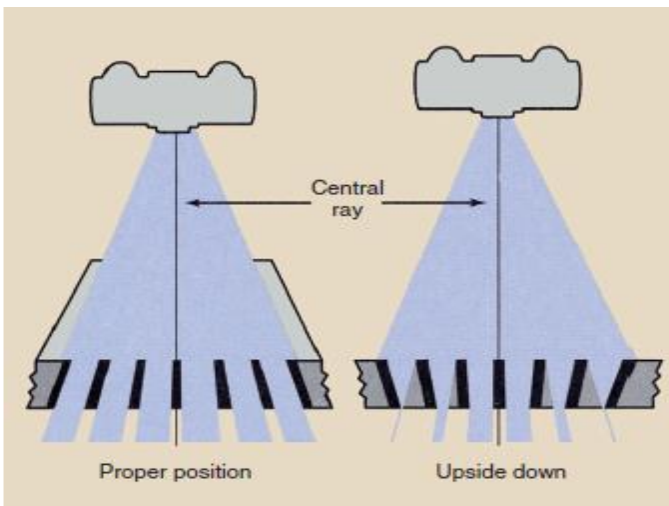


Figure (2.12) upside down grid.

2.1.10 .Grid selection:-

Modern grids are sufficiently well manufactured that many radiologists do not find the grid lines of stationary grids objectionable, especially for mobile radiography and horizontal views of an upright patient (Bushong,2013).

Moving grid mechanisms, however, rarely fail, and image degradation rarely occurs. Therefore, in most situations, it is appropriate to design radiographic imaging around moving grids. When moving grids are used, parallel grids can be used, but focused grids are more common.

Focused grids are in general far superior to parallel grids, but their use requires care and attention. When focused grids are used, the indicators on the x-ray apparatus must be in good adjustment and properly calibrated.

The SID indicator, the source-to-tabletop distance (STD) indicator, and the light-localizing collimator all must be properly adjusted.

Selection of a grid with the proper ratio depends on an understanding of three interrelated factors: kVp, degree of scatter radiation reduction, and patient radiation dose. When a high kVp is used, high-ratio grids should be used as well. Of course, the choice of grid is also influenced by the size and shape of the anatomy that is being radiographed (Bushong ,2013).

As grid ratio increases, scatter radiation attenuation also increases. Figure (2.13) shows the approximate percentage of scatter radiation and primary radiation transmitted as a function of grid ratio. Note that the difference between grid ratios of 12 : 1 and 16 : 1 is small. The difference in patient dose is large, however; therefore, 16 : 1 grids are not often used. Many general purpose x-ray examination facilities find that an 8 : 1 grid represents a good compromise between the desired levels of scatter radiation reduction and patient radiation dose (Bushong,2013).

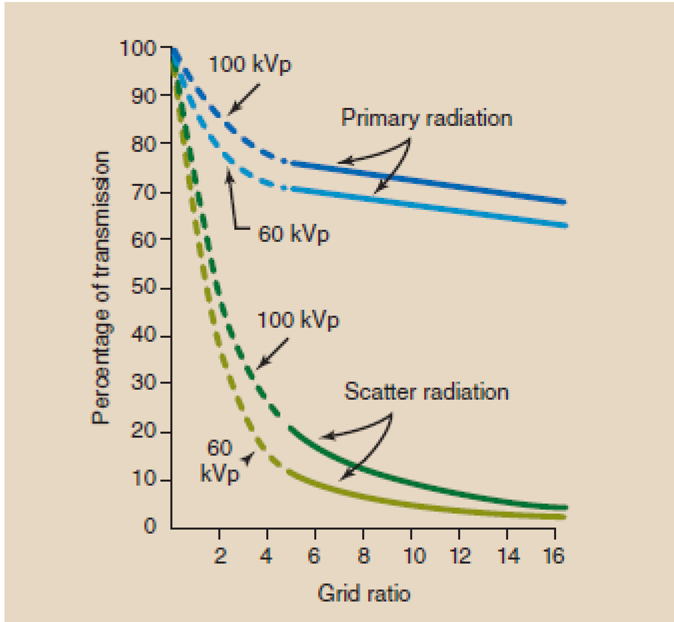


Figure (2.13) Relation between percentage of transmission and grid ratio.

The use of one grid also reduces the likelihood of grid cutoff because improper grid positioning can easily accompany frequent changes of grids. In facilities where high-kVp technique for dedicated chest radiography is used, 16 : 1 grids can be installed (Bushong ,2013).

2.1.11. Patient Dose:-

One major disadvantage that accompanies the use of radiographic grids is increased patient radiation dose. For any examination, use of a grid may result in several times more radiation to the patient than is provided when a grid is not used. The use of a moving grid instead of a stationary grid with similar physical characteristics requires approximately 15% more patient radiation dose. Table (2.2) is a summary of approximate patient doses for various grid techniques with a 400- speed image receptor (Bushong,2013).

Low-ratio grids are used during mammography. All dedicated mammographic imaging systems are equipped with a 4:1 or a 5:1 ratio moving grid. Even at the low kVp used for mammography, considerable scatter radiation occurs.

The use of such grids greatly improves image contrast, with no loss of spatial resolution. The only disadvantage is the increase in patient dose, which can be as much as twice that without a grid. However, with dedicated equipment and grid, patient dose still is very low (Bushong,2013).

Table (2.2) Approximate Entrance Skin Radiation Dose for Examination of the Adult Pelvis with a 400-Speed Image Receptor.

Type of Grid	Entrance Dose(m Gyt)		
	70 kvp	90 kvp	110 kvp
No grid	0.4	0.35	0.25
5:1	1.4	1.1	7.5
8:1	1.6	1.4	1.0
12:1	2.2	2.0	1.5
16:1	2.6	2.4	1.9
5:1crossed	2.6	2.0	1.5
8:1 crossed	2.9	2.7	2.0

2.1.12 .Grid Selection Factors:-

-Patient radiation dose increases with increasing grid ratio.

-High-ratio grids are used for high-kVp examinations.

-The patient dose at high kVp is less than that at low kVp.

A clever technique that may be used as an alternative to the use of radiographic grids is the air-gap technique. This is another method of reducing scatter radiation, thereby enhancing image contrast. When the air-gap technique is used, the image receptor is moved 10 to 15 cm from the patient figure (2.14). A portion of the scattered x-rays generated in the patient would be scattered away from the image receptor and not be detected. Because fewer scattered x-rays interact with the image receptor, the contrast is enhanced (Bushong ,2013).

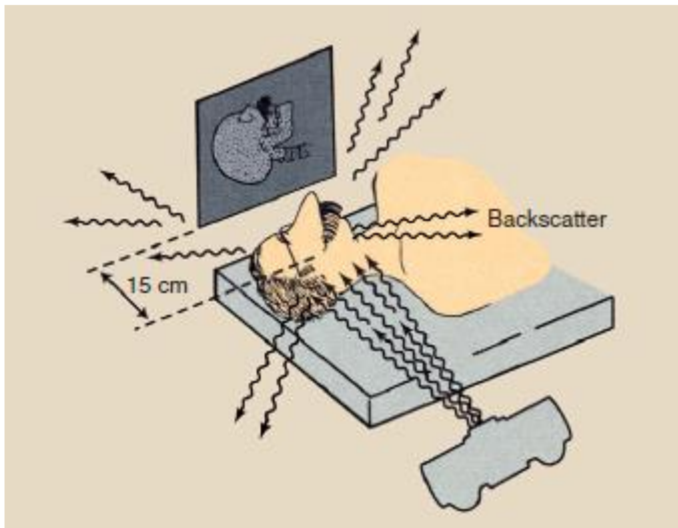


Figure (21.4) Air-gap technique.

2.2. previous studies:-

In study by M.L Ebisawa et al in 2009, Evolution of X-ray machine quality control acceptance indices in Brazil, routine quality control based on acceptable limits for variations between nominal and measured parameters as the variable to determine the equipment operating conditions for equipment's . The data analyzed for conventional X-rays indicated that only 51% of the grids were adequate in 2000; this index decreased to 37%, while 2004 and 2006 presented significant improvements, with the conformity rate increasing to 74% and 86.6%, respectively. The abrupt increase of this index in 2004 reflects a change in the methodology to evaluate grid alignment, as introduced by Sapra Assessoria (Ebisawa et al, 2009).

Another study by Z Behrouzkia et al in 2015, Assessment of Radiation Protection Practices amongst Radiographers and Quality Control of Diagnostic Radiology Devices in the Selected Hospitals of Urmia City in Iran, the study was to perform of the important features of QA tests and radiation safety factors in major medical X-ray installations in urmia, iran. The analysis of the results of the central ray when moved over the other holes of the grid alignment test tool showed the optical densities of the corresponding dot on the film were decreased symmetrically away from the central dot ,that was indicated to grid alignment for x-ray machine which tested (Behrouzkia et al, 2015).

Chapter three

Materials and Methods

3.1.Materials:-

3.1.1.Study Sample:-

A 15 x-ray units in different computed radiology departments in Khartoum state. The x-ray units where manufactured by Toshiba, Philips, shimazo, floatex and Siemens.

3.1.2.Test Tools:-

RMI Quality assurance in radiology test was pleased on couch of x-ray machine. The test consist of a set of three plastic-covered, 0.062 inch thick lead plates: one 9.125 x 3.625 inch test plate, and two 3.56 x 2.375 inch blocker plates. The large test plate was contained five 0.375 inch test holes and five 0.062 inch orientation holes. It had serial number 1432149. Then the Fuji IP film cassette type CC size(35.4x35.4)cm and Kodak film size (25.4x30.5)cm were used. Finally the radiographic films was also used in testing tools.

3.2.Method:-

3.2.1. Technique Used:-

This research is mainly built on experimental work , which is done by grid alignment test tools from different radiology department (x-ray machines) in Khartoum state. The test tool contains five holes which are evenly spaced apart and three smaller holes at one end to aid in determining the tool's orientation. Film-screen cassette was also used in this test and was placed in the Bucky mechanism. It was also important to ensure that the beam was centered to the Bucky; this was done with the help of the centering laser light on the x-ray tube. The grid alignment test was then performed by taking an exposure centered over each hole while the others were covered by lead strips. An exposure is also required for the three holes at the end of the test tool. Each hole was exposed using 55 kVp, 3.2mAs and with the x-ray tube set at a 100 cm SID to the table Bucky. The film was then processed and the resulting radiograph film along with images of the grid alignment test process.

3.2.2 .Measurements:-

The optical density for each hole in radiographic film was read by X-RIDE 331 B/W Transmission Densitometer (4-6) volts Dc, serial number 033173 and made in U.S.A. Then the results were tabulated and compered with each other's.

3.2.3. Data Analysis Method:-

The data were analyzed by computer program Excel software version 2010 which all the obtained measurements were used to compare between the alignment and misalignment grid in radiology departments in Khartoum state.

Chapter four

Results

Table (4.1) shows the x-ray machines frequency and percentage which used in grid alignment test according to manufactures.

Manufactures of x-ray machines	Frequency	Percent
Toshiba	10	66.7%
Philips	2	13.3%
Floatex	1	6.7%
Siemens	2	13.3%
Total	15	100%

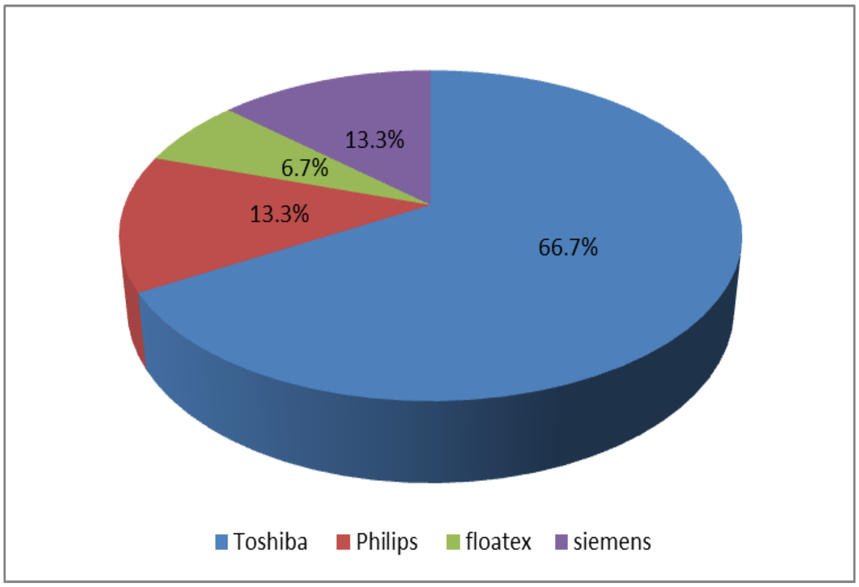


Figure (4.1) shows the x-ray machines frequency and percentage which used in grid alignment test according to manufactures.

Table (4.2) shows the x-ray machines frequency and percentage which used in grid alignment test according to ages.

Equipment Age	Frequency	Percent
2000-2005	2	13.3%
2006-2010	10	66.7%
2011-2015	3	20%
Total	15	100%

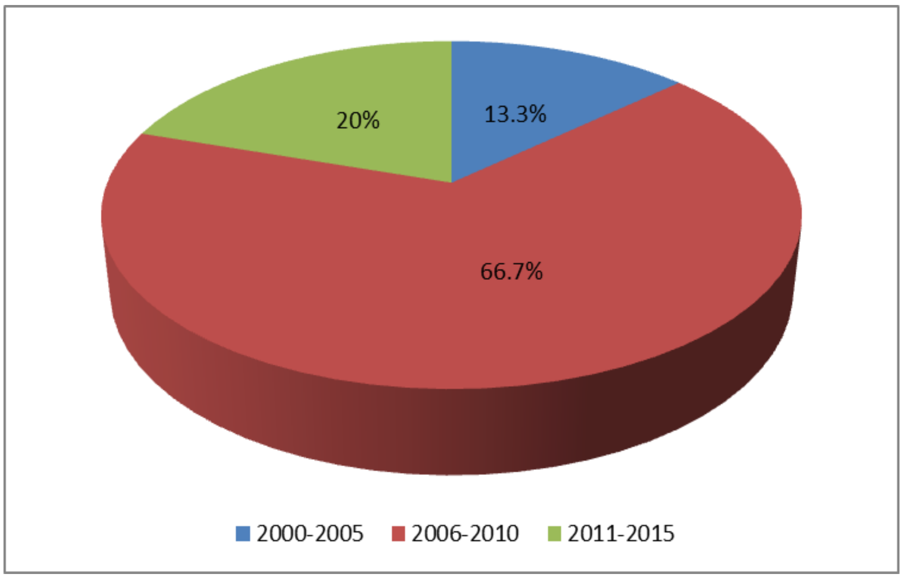


Figure (4.2) shows the x-ray machines frequency and percentages which used in grid alignment according to ages.

Table (4.3) shows the results of grid alignment test for align and misalignment x-ray units and their percentage.

Grid alignment performance	Number x-ray units	Percent
Grid alignment	5	33.3%
Grid misalignment	10	66.7%
Total	15	100%

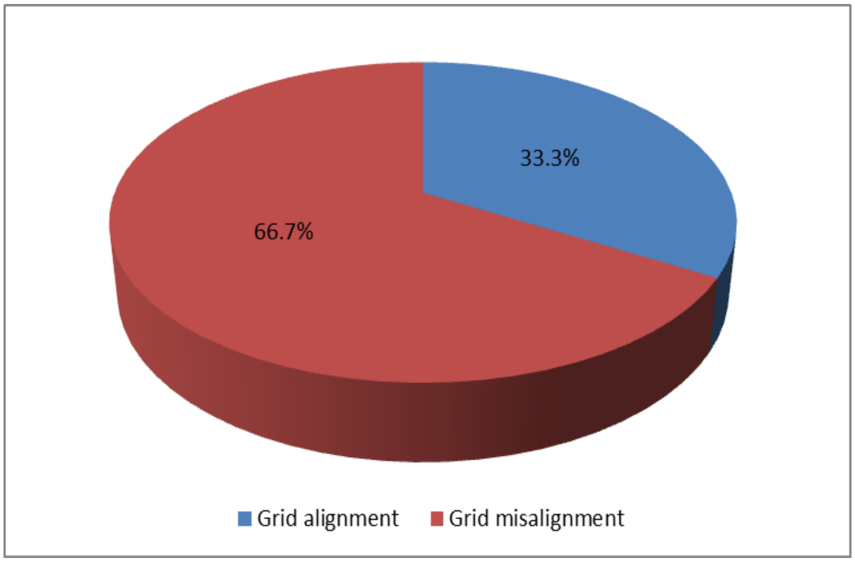


Figure (4.3) shows the percentage of grid alignment and misalignment in x-ray machines which tested.

Table(4.4) shows the optical density obtained for each hole in grid alignment test for alignment machines.

X-ray machines number	OD h1	OD h2	OD h3	OD h4	OD h5
1	0.47	0.51	0.56	0.54	0.51
2	1.17	1.19	1.32	1.24	1.08
3	0.65	0.82	0.9	0.87	0.83
4	1.08	1.13	1.23	1.16	1.02
5	0.7	1.19	1.54	1.26	0.85

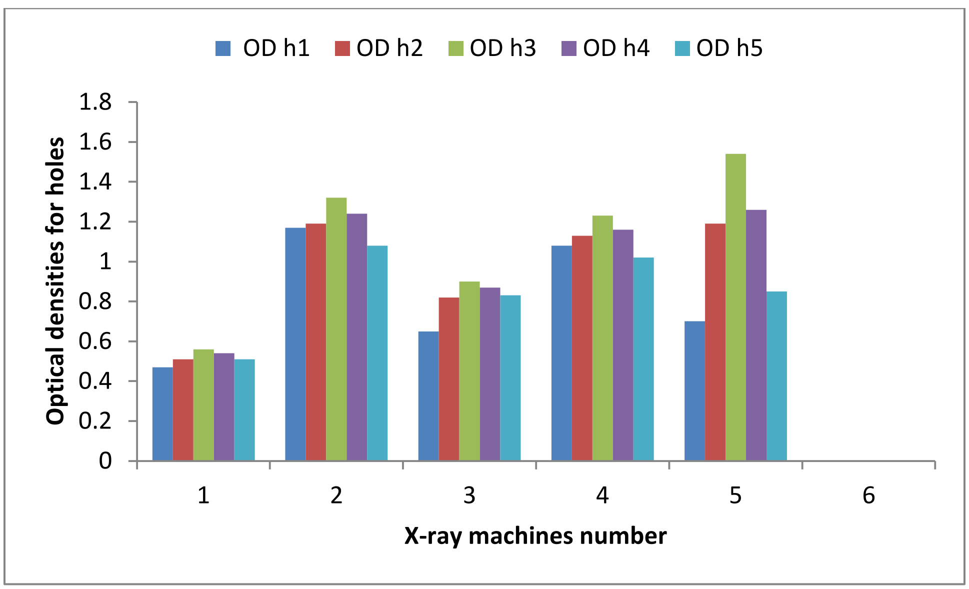
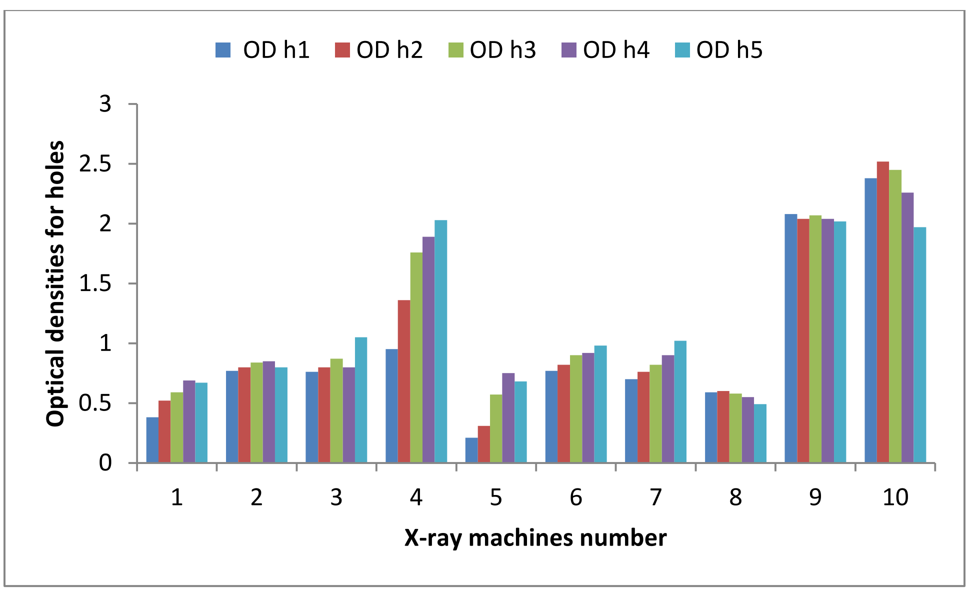


Figure (4.4) shows optical densities for grid alignment machines.

Table (4.5) shows the optical density obtain for each hole in grid alignment test for misalignment machines.

X-ray machines number	OD h1	OD h2	OD h3	OD h4	OD h5
1	0.38	0.52	0.59	0.69	0.67
2	0.77	0.8	0.84	0.85	0.8
3	0.76	0.8	0.87	0.8	1.05
4	0.95	1.36	1.76	1.89	2.03
5	0.21	0.31	0.57	0.75	0.68
6	0.77	0.82	0.9	0.92	0.98
7	0.7	0.76	0.82	0.9	1.02
8	0.59	0.6	0.58	0.55	0.49
9	2.08	2.04	2.07	2.04	2.02
10	2.38	2.52	2.45	2.26	1.97



Figure(4.5) shows optical densities for grid misalignment machines.

Chapter five

Discussion, Conclusion and Recommendation

5.1. Discussion:-

This study has been done one 15 radiology departments in Khartoum state. The main objective was to assess the grid alignment for x.-ray machines in radiology departments.

This study showed that there low percentage of grid alignment (33.3%) for x-ray machines while percentage of grid misalignment was (66.7%) for study sample that expressed in table and figure(4.3), compare with study by (M.L Ebisawa et all, (2009)) when showed 51% of grid was alignment which index increased to 74% and 86% in 2004 and 2006 respectively due to significant improvement our result index for grid alignment is less may be due to poor maintenance or absence of quality control tests.

In grid alignment machines as showed optical density variation for central hole (h3) had a value (0.56,1.32,0.9,1.23and 1.54) that illustrated in table(4.4) for 5 x-ray unit created the greatest density of corresponding dot on the film and decreased symmetrically away from center that means the grid was alignment, while in grid misalignment results for other 10 x-ray machines the optical density for central hole (h3) created value not larger than the other holes ether increasing in h4 and h5 that called outward off-center grid due to (misused by radiographer) in x-ray machines number from 1 to 7 about 70% from the grid misalignment that illustrated in table(4.5) or increasing in h1and h2 that called inward off-center grid due to (lack of good installation by medical engineering) in x-ray machines number 8,9and10 about 30%, that according to experts said.

Our results showed that there is no relation between installation date of machine and grid misalignment. As example of old machine installed in 2000 was alignment and new machine installed in 2013 was misalignment. In addition, the manufacture had no effect for grid misalignment.

5.2. Conclusion:-

In conclusion, according to results from the study of grid alignment for radiology department in Khartoum state the great percentage of x-ray units in departments were grid misalignment by ether inward off-center grid or by outward off-center grid.

Most of Khartoum state radiology departments will not applied the quality assurance and quality control because of absence of quality assurance tools and financial cost and most of x-ray departments do not implemented quality control program.

5.3. Recommendation:-

-A radiology department needs to have QA program in all departments of Khartoum state and routine quality control should be implemented to the x-ray machines.

-Health provider should support and encourage staff in radiology department to appreciate the importance of an effective quality control program.

-There should be awareness by important of research. The health law must be more flexible than it is now to facilitate the research procedure.

-The future studies should include a large number of x-ray machines in the radiology departments in Khartoum state in addition to all quality control tests for equipment.

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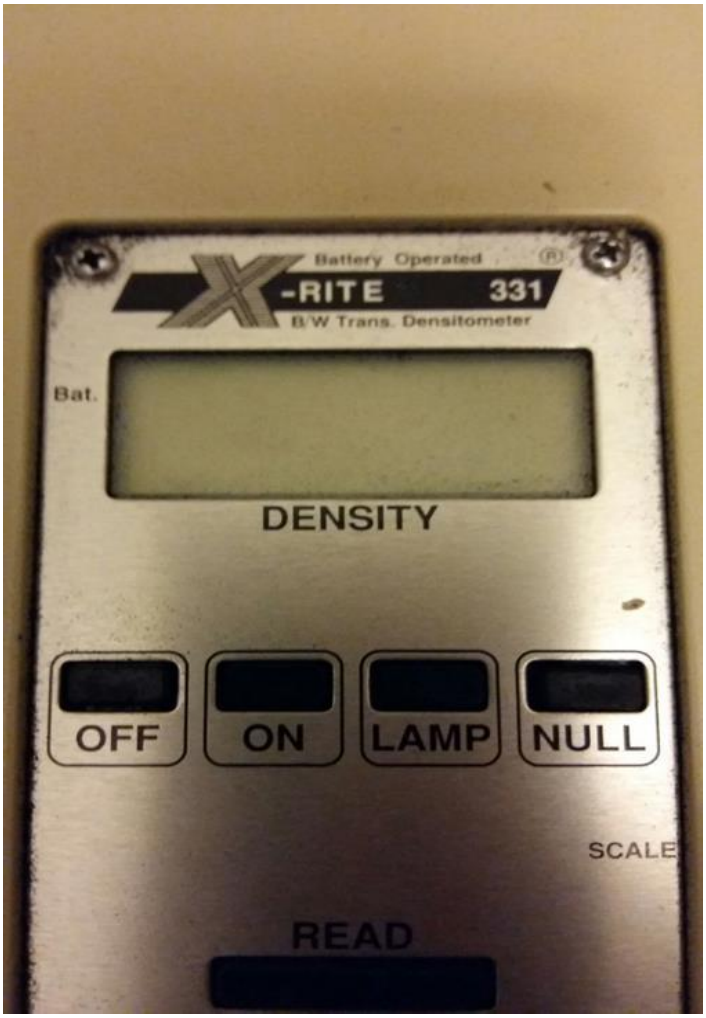
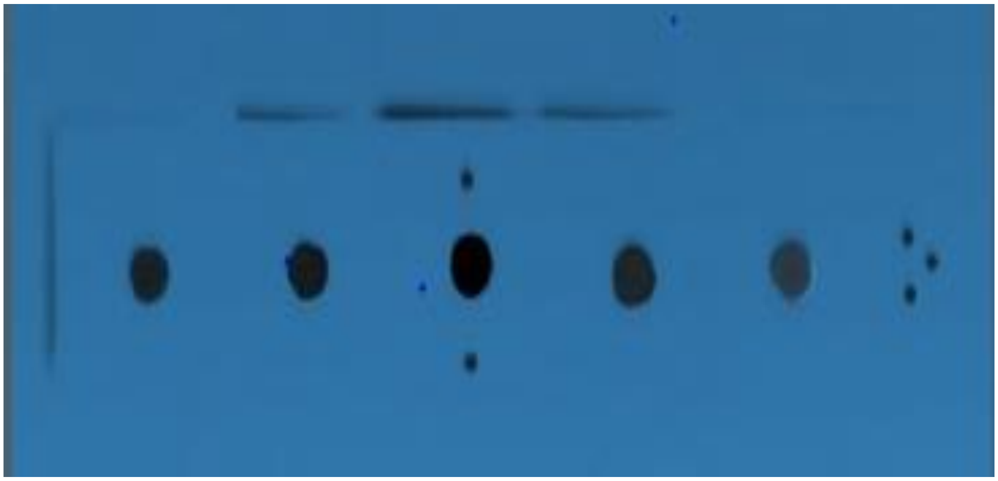
Appendixes

Grid alignment test tools.

X-ray machine centering with Bucky.

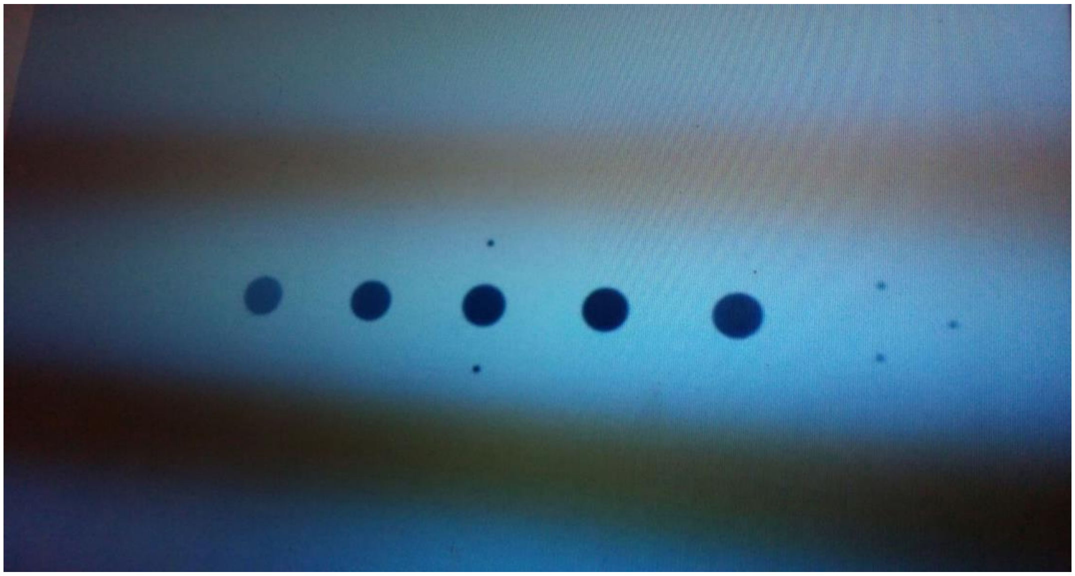


Transmission densitometer.



Example for grid alignment.

OD h1	OD h2	OD h3	OD h4	OD h5
0.47	0.51	0.56	0.54	0.51



Example for grid misalignment.

OD h1	OD h2	OD h3	OD h4	OD h5
0.38	0.52	0.59	0.69	0.67