Sudan University of Science and Technology

College of Graduate Studies

Evaluation of Entrance Skin Dose in the Periapical Dental X-ray Examination

تقييم الجرعة الداخلة إلي الجلد أثناء تصوير الأسنان بالأشعة السينية

A Thesis Submitted For Partial Fulfillment of M.sc Degree in Medical Physics

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2021

الآية

بسم الله الرحمن الرحيم

قال تعالى:

اقْرَأْ بِاسْمِ رَبِّكَ الَّذِي خَلَقَ (1) خَلَقَ الإِنسَانَ مِنْ عَلَقٍ (2) اقْرَأْ وَرَبُّكَ الأَكْرَمُ (3) الَّذِى عَلَّمَ
بِالْقَلَمِ (4) عَلَّمَ الإِنسَانَ مَا لَمْ يَعْلَمْ (5)

صدق الله العظيم

سوره العلق من الآية (1) الي الآية (5)

DEDDICATION

I WOULD LIKE TO DEDICATE THIS WORK TO SOUL OF MY FATHER, AND MY GREAT MOTHER, MY LOVELY FAMILY AND FRIENDS…

ACKNOWLEDGMENT

First of all, I thank Allah the Almighty for helping me complete this research. I thank Prof: Caroline Edward, my supervisor for help and guidance.

I would like to express my gratitude all staff of the radiological unit in Khartoum Dental Educational Hospital for great help and support.

Finally I would like to thank everybody who helped me to prepare and finish this study.

Abstract

High doses of ionizing radiation can lead to adverse health outcomes such as cancer induction in humans. Although the consequences are less evident at very low radiation doses, the associated risks are of societal importance. This study aimed to evaluate entrance skin doses (ESDs) in the periodical DentalX-rayexaminations.

The entrance skin dose (ESD) was measured for 200patient in both gender underwent dental X-ray examination at Radiology Department of Khartoum Dental Educational Hospital during the period extended for December 2019 to February2020. The entrance skin dose ESD was determined via measured parameters: focus to skin distance (FSD), tube current (mAs) and tube voltage (kV).

Used of conventional X-ray dental units used within the safety range, the mean ESD values obtained were found to be within the standard international Reference, there is no different in the ESD between upper and lower jaw, On the basis ofthe results obtained in this study the ESD dose was measured for the upper and lower jaw and was found to be (0.017425, 0.016475) in respectively.

Conclusion:Entrance surface dose were estimated in the present study for patients undergoing selected dental X-ray examination in Khartoum dental educational hospital.

The mean of ESD values of upper and lower jaw in the hospital respectively (0.017425, 0.016475 mGy) less than reference levels recommended by ICRP (1.2 mGy), and no different in dose between the upper and the lower jaw.

ملخص البحث

الجرعات العالية من الإشعاع المؤين يمكن أن تؤدي إلي نتائج صحيه سلبيه مثل تحريض مرض السرطان في البشر. وعلي الرغم من أن العواقب تكون أقل وضوحا عند الجرعات الإشعاعية المنخفضة جدا، فإن المخاطر المرتبطة بها ذات أهمية إجتماعية. وتهدف هذه الدراسة إلي تقييم الجرعة المدخلة في المرضي الذين يخضعون لتصوير الأسنان لأشعة إكس.

وقياس الجرعة الداخلة للجلد تلقي من قبل 200 مريض تحت إختبار فحص الأسنان بالأشعة السينية في مستشفي الخرطوم التعليمي للأسنان منديسمبر 2019 إلي فبراير 2020 .

تم تحديد الجرعة الداخله للجلد من خلال قياسات الكميات المتغيرة: التركيز علي مسافة الجلد(FSD)، التعرض الزمني بالنسبة للتيار (mAs) وأنبوب الجهد(KV) .

تم إستخدام جهاز الأشعة السينية في مستوي الأمان للإشعاع ،و وجد أن متوسط قيم الجرعة الداخلة للجلد التي تم الحصول عليها تكون ضمن المعيار المرجعي العالمي،ولا يوجد إختلاف بين تصوير الفك الأعلي والأسفل، وإعتمادا علي النتائج المتحصل عليها في هذه الدراسة وجد أن الجرعة الداخلة للجلد بالنسبة للفك الأعلي والأسفل(0.017425, 0.016475mGy) بالترتيب.

الخاتمة: قدرت الجرعة الداخلة للجلد في هذة الدراسة للمرضي الذين خضعوا لإختبار فحص الأسنان بالأشعة السينية في مستشفي الخرطوم التعليمي للأسنان وجد أن متوسط قيمة الجرعة الداخلة للجلد للفك الأعلي و الأسفل علي التوالي (0.017425, 0.016475 mGy) أقل من القيمة المرجعية الموصي بها بواسطة الوكالةالدولية للوقاية من الإشعاع (1.2 mGy) ، ولا فرق في الجرعة بين الفك الأعلي والأسفل.

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List of Abbreviations

Abbreviation	**Phrase**
DNA	Deoxyribonucleic acid
DRL	diagnostic reference Level
ESD	Entrance surface dose
FFD	Focus to film distance
FSD	Focus skin distance
Gy	Gray
HVL	Half value layer
IAEA	International Atomic Energy Agency
ICRP	International Commission On radiation protection
KVP	Kilo voltage peak
mAs	Milli ampere second
MeV	Mega electron volt
NRPB	National radiation protection board
OP	Out put
PDD	Percentage depth dose
QC	Quality control
SID	Source to image distance
SOD	Source to object distance
SSD	Surface skin distance
Sv	Severt
TLD	Thermo luminescence dosimeter

CHAPTER ONE

Introduction

CHAPTER ONE

1.1 Introduction:-

Dental X-ray is the most frequently used ionizing radiation for diagnostic imaging and it plays a significant role in effective health care delivery both in developed and developing countries.The need for radiation dose assessment of the patient during dental x-ray examinations has been highlighted by increasing knowledge of hazard of ionizing radiation because of the deleterious effects of x-ray,it is necessary to protect patients undergoing diagnostic procedures.

The aim of any diagnostic x-ray examination is to produce images of sufficient and optimum quality (sami, 2015).

Many of early pioneers in dental radiography suffered from adverse effects of ionizing radiations.The role of the dental radiography is to achieve a high protection to the patient before,during,and after exposure to x-rays.with the use of proper patient protection techniques,the amount of radiation received by the patient can be minimized.The first important step in reducing the amount of x-radiation a dental patient receives is the proper prescribing of dental radiographs.There should be professional judgment to make decisions about the number,type,and frequency of dental radiographs.

The dental radiographer must use proper protection measures to avoid exposure to primary radiation,leakage radiation and scatter radiation.The dental radiographer should never expose to the primary beam and limit x-ray exposure is to maintain an adequate distance is not possible,a protective barrier must be used.

Entrance skin dose (ESD) is amount of skin absorbed dose at the entrance point of the x-ray beam(Hanan, 2007).

Measurement of ESD is usually required for a specific type of radiography if deterministic effects are possible.Entrance skin dose can be measured directly on the patient by thermo luminescent dosimeter (TLDs) or can be derived from measurements of incidence absorbed dose (ID) by multiplying by the backscatter factor.

TLDs are considered as the gold standard for determination of the entrance skin dose in practice. Measurements are made with (TLDs) attached to the patient or phantom at points where the dental x-ray beam enters the patient. TLDs are read in a stander manner and the value read is used as an estimate of the ESD received by the patient. If correctly calibrated to measure air kerma free in air. The TLD should give a direct reading of the entrance skin dose and no correction factor is needed for backscattered radiation or distance from the focus (sami, 2015).

The aim of this work is to assessment the entrance skin dose (ESD) for dental x-ray examination in Khartoum Dental Education Hospital. The results obtained will compare with reference dose levels (RDLs).

1.2 Problem of the study:-

Many departments do not use recommended exposure factor parameter for dental x-ray examination. Wide variation was found in techniques, equipment performance and radiation dose in difference hospital over the world.

The question to be answered:

a- What is the ESD used during dental X-ray examination.

b- Are the dental machine used in the radiology department safe for patients.

1.3 Objectives:-

1.3.1 General objective:-

To evaluate of Entrance skin dose in the periodical Dental X-ray examination.

1.3.2 Specific objectives:-

1- To compare the ESD of the upper and lower jaw (central incisor-canine-premolar-molar).

2- To correlate the dose with age.

1.4 Significant of the study:-

Radiation dose to the patients and its management have become important considerations in diagnostic radiographic imaging procedures, Thereforedose in patient radiography be minimized, while simultaneously ensuring sufficient diagnostic information in the image, and reducing the need for repeat exposures.

CHAPTER TWO
LITERATURE REVIEW

CHAPTER TWO
LITERATURE REVIEW

Background radiological physics:

2.1 Radiation:

Radiation is energy that travels through space or matter. Two categories of radiation of importance in medical imaging are electromagnetic (EM) and particulate (Bushbergetal, 2012).

2.1.1 Electromagnetic Radiation:

Radio waves, visible light, x-ray and gamma rays are different types of EM radiation.

EM radiation hasno mass, is unaffected by either electric or magnetic fields, and has a constant speed in a given medium.

EM radiation is commonly characterized by wavelength, frequency, and energy per photon (E). EM radiation over a wide range of wavelengths, frequencies and energy per photon comprises the EM spectrum.

Several forms of EM radiation are used in diagnostic imaging. Gamma rays, emitted by the nuclei of radioactive atoms, are used to image the distributions of radiopharmaceuticals. X-rays produced outside the nuclei of atoms, are used in radiography, fluoroscopy, and computed tomography (Bushbergetal, 2012).

2.1.2 Wave-Particle Duality:

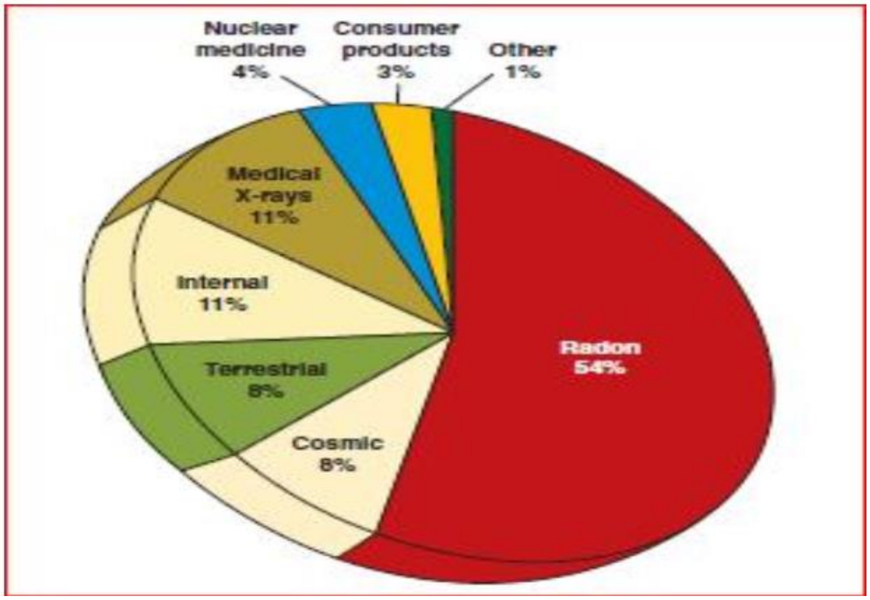
There are two equally correct ways of describing EM radiation- as waves and as discrete particle like packets or quanta of energy (Bushbergetal, 2012).

2.2 Radiation sources:

Source of radiation can be divided into two categories:

2.2.1natural radiation sources:

It is the radiation exposure to man occurs from natural sources e,g cosmic rays, and terrestrial sources that comes from radionuclide’s in the earth’s crust, air, food and water and the human body itself (Bushbergetal, 2012).



Figure(2-1) radiation sources (Steve 2011)

2.2.2 Man-made sources:

Exposure to population occurs mainly from medical uses of radiation and radioisotopes in health care, occupational sources in the generation of electricity from nuclear power reactors, industrial uses of nuclear techniques, and in the past from nuclear weapons testing(sami, 2015).

2.3 Discovery of X-rays and its characteristics:

X-rays were accidentally in 1985, when William C.Roentgen was experimenting with a cathode ray tube. Roentgen was working in this laboratory at Wurzburg University in Germany.

He had darkened his laboratory and completely enclosed his tube with a back paper so that he could better visualize the effects of the cathode rays in the tube a plate coated with barium platinocyanide (a fluorescent material) happened to be laying on a bench top several feet's from the tube he was using. No visible light escaped from his tube because of the black paper enclosing the tube, but Roentgen noted that the barium platinocyanidefluorescedregardless of its distance from the tube.Because the cathode rays. Roentgen was studding could not travel more than a few centimeters in air he concluded that the source of that glow of the plate he noted was another kind of unknown rays. He called these unknown rays as X-ray.

X-rays now play an important role in health life of all communities. Its examinations are now the most common examination in all hospitals(sami, 2015).

2.4 Interaction of x-ray:

2.4.1 Excitation:

In this interaction, the projectile electrons interact with the outer shell electrons of the target atoms, the outer shell electrons get excited and raised to higher energy levels. The outer shell electrons then immediate drop back to the normal energy state with the emission of infrared radiation. In the x-ray tube this emitted infrared radiation heat the anode of the x-ray tube(sami, 2015).

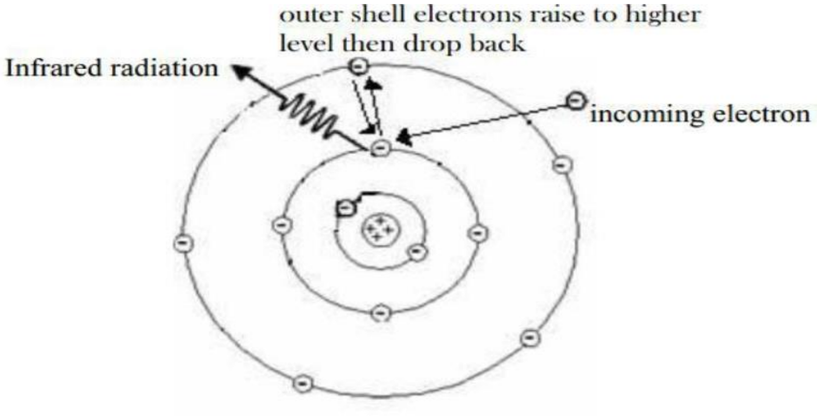


Figure 2.2Excitation process(Sami, 2015)

2.4.2 Ionization:

In this interaction the projectile electrons interact with inner shell electrons where the energy of the incident electrons exceed the binding energy of the electrons in their shells, these inner shell electrons as a result get ejected from their inner orbits of the target atom and the atom gets ionized and a hole is created in the place of the ejected electron. This hole is then filled by an electron from a higher energy level and characteristic x-ray lines are produced. These x-rays are called characteristic because its energy is specific to the target element(Sami ,2015).

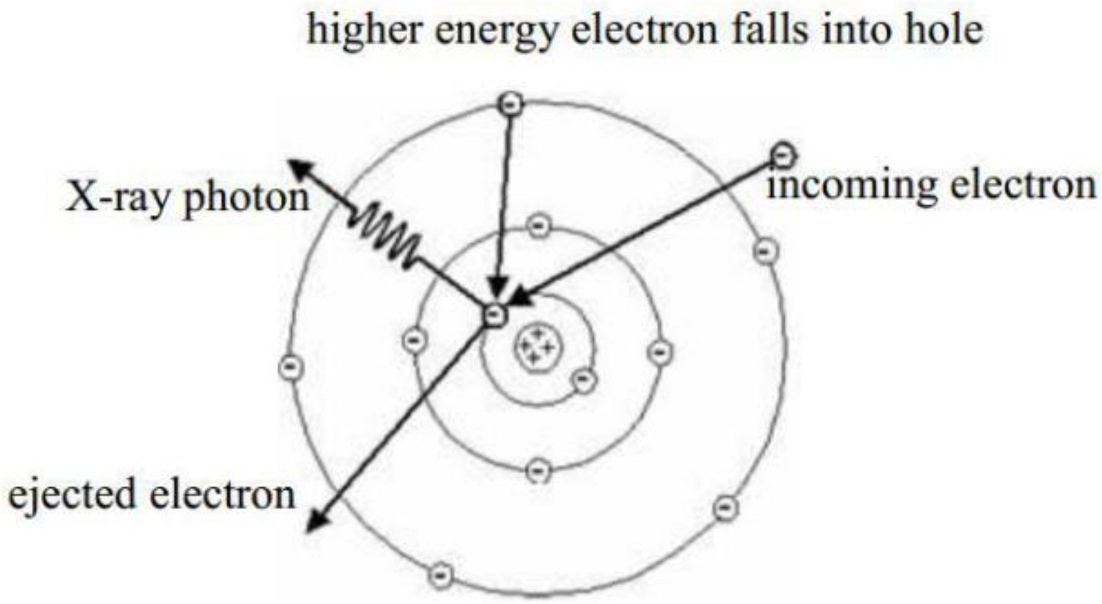


Figure 2.3 Ionization process(Sami, 2015)

2.4.3 Bremstrahlung:

In this interaction the electrons completely avoid the orbital electrons and come sufficiently close to the nucleus of the atom. The electrons are attracted by the strong electric field of the nucleus which causes a sudden change in the motion of the electrons and constitutes a violent deceleration that disturbs the electromagnetic field and a photon is emitted. At each interaction an x-ray is produced, which may have energy between zero and a maximum value egual to the initial kinetic energy of the incident electron(Sami, 2015).

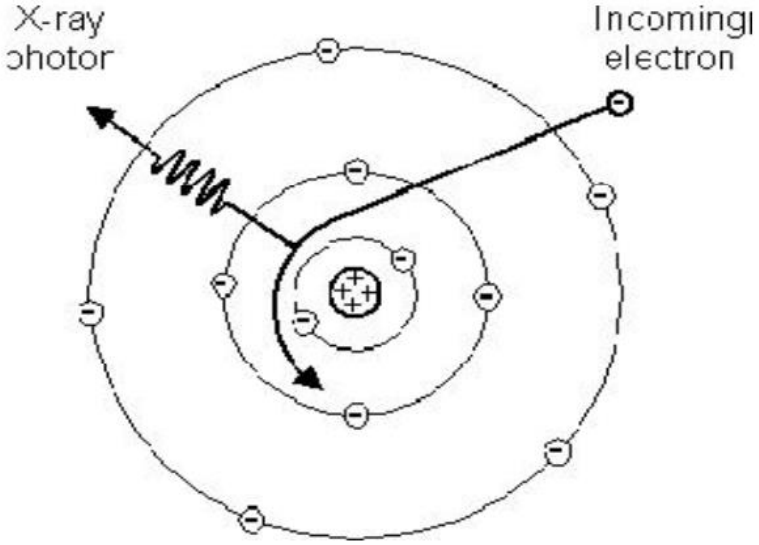
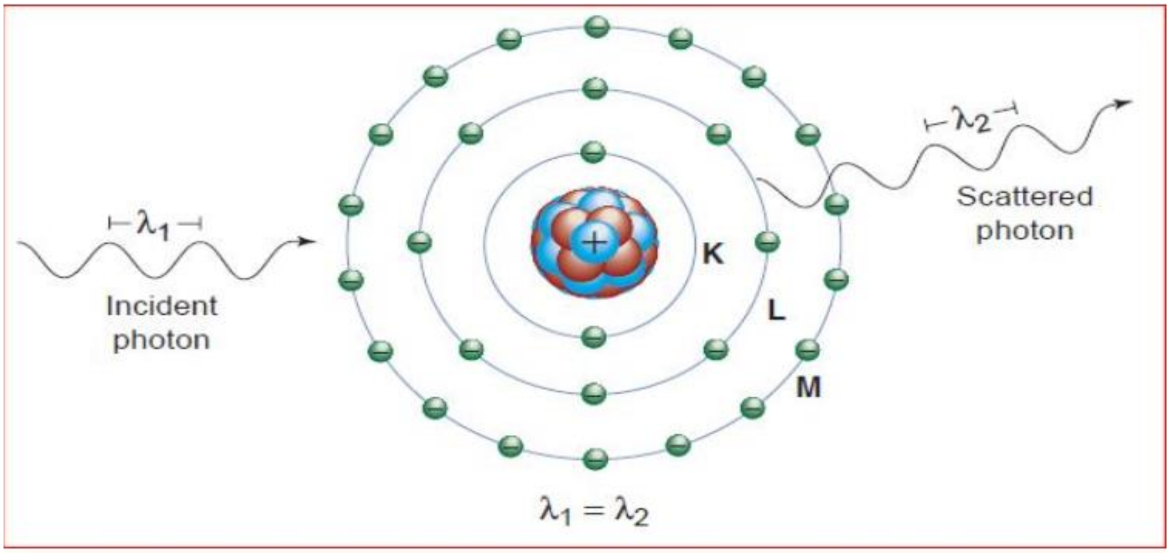


Figure 2.4Bremstrahlung process(sami,2015)

2.5 Photon interaction with matter:

2.5.1 Rayleigh scattering:

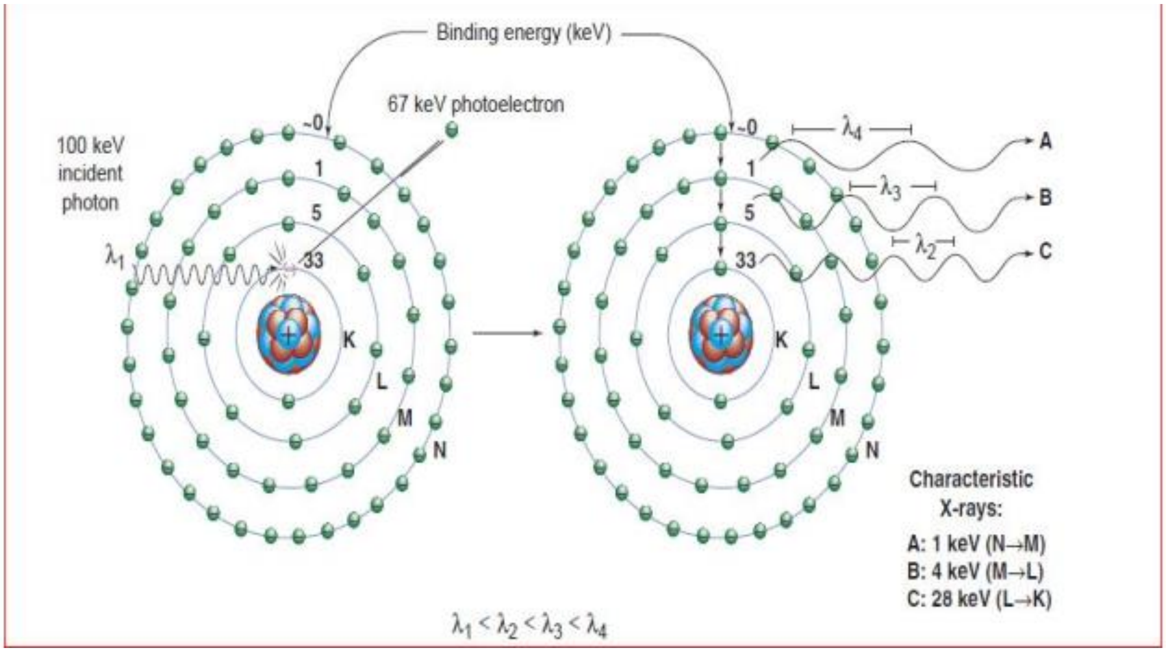
In Rayleigh scattering, the incident photon interacts with and excites the total atom as opposed to individual electrons an in Compton scattering or the photoelectric effect. This interaction occurs mainly with very low energy x-rays, such as those used in mammography (15 to 3o keV). During the Rayleigh scattering event, the electric field of the incident photon’s electromagnetic wave expends energy, causing all of the electrons in the scattering atom to oscillate in phase. The atom’s electron cloud immediately radiates this energy emitting a photon of the same energy but in slightly different direction. in this interaction, electrons are not ejected, and thus, ionization does not occur. In general, the average scattering angle decreases as the x-ray energy increases. In medical imaging, detection of the scattered x-ray will have a deleterious effect on image quality. However, this type of interaction has a low probability of occurrence in the diagnostic energy range. In soft tissue, Rayliegh scattering accounts for less than 5% of x-ray interactions above 70 keV and at most only accounts for about 10% of interactions at 30 keV. Rayleigh interactions are also referred to as “coherent” scattering(Bushbergetal, 2012).



Figure(2.5)Rayleigh scattering(Bushbergetal, 2012)

2.5.2 Photoelectric effect:

In the photoelectric, all of the incident photon energy is transferred to an electron which is ejected from the atom. The kinetic energy of the ejected photoelectron (Epe) is equal to the incident photon energy (E0) minus the binding energy of the orbital electron (Eb) in order for photoelectric effect absorption to occur, the incident photon energy must be greater than or equal to the binding energy of the electron that is ejected. The ejected electron is most likely one whose binding energy is closest to, but less than, the incident photon energy(Bushbergetal, 2012).



Figure(2.6)photoelectric effect(Bushbergetal, 2012)

2.5.3 Compton scattering:

Compton scattering (also called inelastic or no classical scattering) is the predominate interaction of x-ray and gamma ray photons in the diagnostic energy range with soft tissue. In fact, Compton scattering not only predominates in the diagnostic energy range above 26 keV in soft tissue but also continues to predominate well beyond diagnostic energies to approximately 30 Mev. This interaction is most likely to occur between photons and outer (“valence”)-shell electrons. The electron is ejected from the atom, and the scattered photon is emitted with some reduction in energy relative to the incident photon. As with all types of interactions, both energy and momentum must be conserved. Thus, the energy of the incident photon (E0) is equal to the sum of the energy of the scattered (Esc) and the kinetic energy of the ejected electron (Ee2).the binding energy of the electron that was ejected is comparatively small and can be ignored. Compton scattering results in the ionization of the atom and a division of the incident photon’s energy between the scattered photon and the ejected electron. The ejected electron will lose its kinetic energy via excitation and ionization of atoms in the surrounding material(Bushbergetal, 2012).

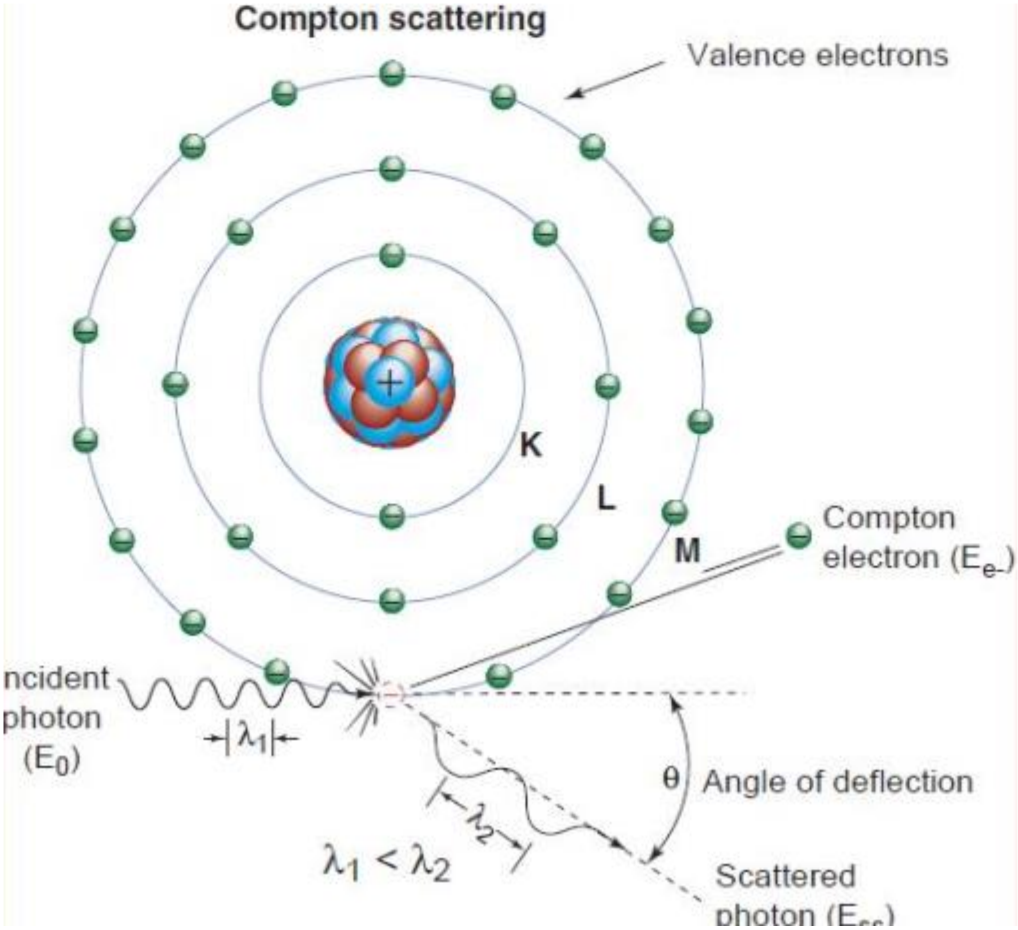


Figure (2.7) Compton scattering(Bushbergetal, 2012)

2.5.4 Pair production:

Pair production can only occur when energies of x-rays and gamma rays exceed 1.02 Mev. In pair production, an x-ray or gamma ray interacts with the electric field of the nucleus of an atom. The photon’s energy instars formed into an electron-positron pair. The rest mass energy equivalent of each electron is .0511 Mev, and this is why the energy threshold for this reaction is 1.02 Mev. Photon energy in excess of this threshold is imparted to the electron (also referred to as negatron or beta minus particle) and positron as kinetic energy. The electron and positron loosen their kinetic energy via excitation and ionization(Bushbergetal, 2012).

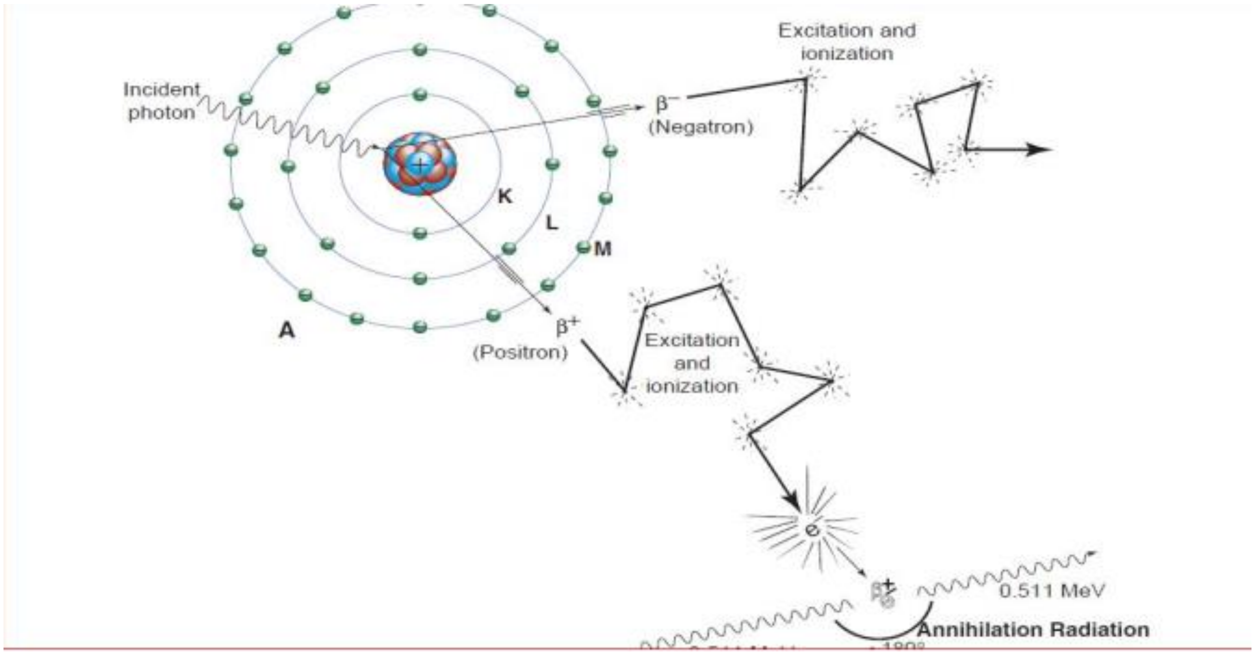
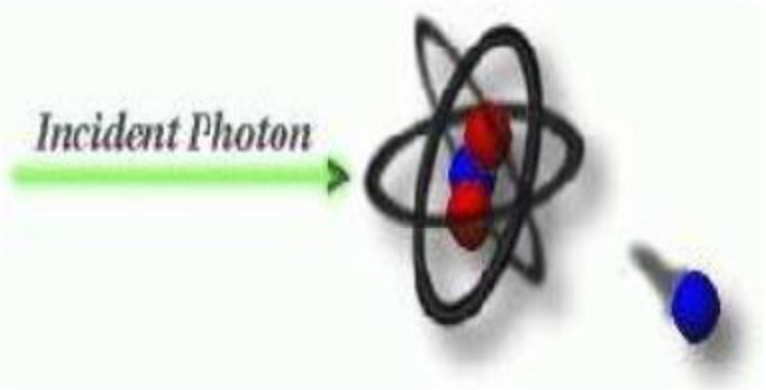


Figure (2.8) pair production(Bushbergetal, 2012)

2.5.5 Photodisintegration:

In this interaction the incident photon has energy greater than 10 Mev and hence it interacts directly with the nucleus and split it in part with emission of neutrons. Because of the high photon energy required for this interaction does not occur in diagnostic x-ray and as such plays no role (Bushbergetal, 2012).



Figure(2.9) Photodisintegration(Bushbergetal, 2012)

2.6 X-ray beam characteristics:

X-ray beam can be described by its quality and or its quantity. Each of these characteristic is discussed separately in the following sections(Bushbergetal, 2012).

2.6.1 X-ray beam quantity:

The x-ray beam quantity is the x-ray intensity (number of photon per unit area per unit time) or the radiation exposure, and is affected by the change in any of the following factors: Milliamper seconds, kvp and distance and filtration.

Milliamper seconds: (mAs) is the product of x-ray tube current by the time of exposure, it controls the number of electrons accelerated towards the anode. If the current is doubled, twice as many electrons will flow from the cathode to the target, and hence twice as much x-ray photons will be produced.

X-ray quantity is proportional to the mAs thus:

$$\mathbf{I_1/I_2=mAs_1/mAs_2}$$

Where $I_0$is the x-ray intensity that is produced when a current mAs_1, is applied on the tube, and $I_2$is the x-ray intensity that is produced when current mAs_2 is applied on the tube. Thus increasing x-ray tube current will also increase x-ray quantity with the same ratio (figure 2.11) (sami, 2015).

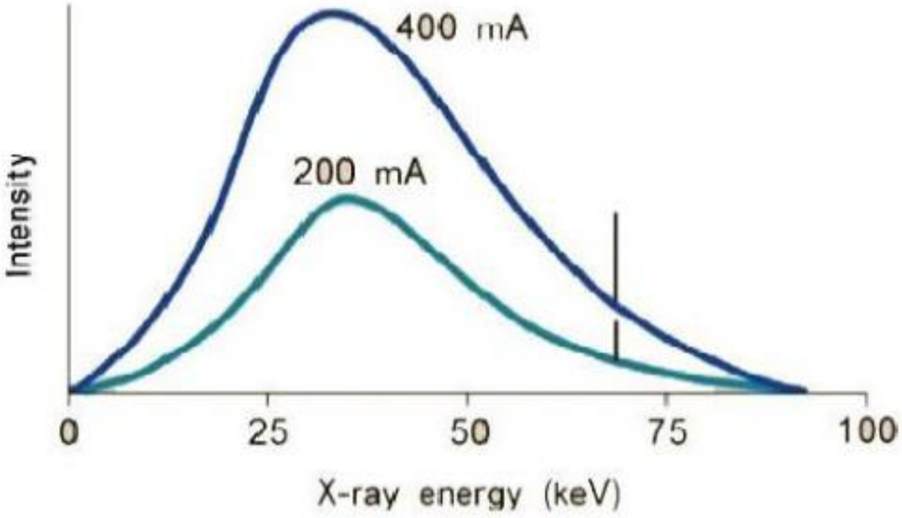


Figure (2.10): Effect of Tube current on X-ray spectrum (Hanan, 2007)

Applied voltage (kvp): The increase in the applied voltage will increase the probability of bremstruhlung interaction and hence more x-ray photon will be produced. It was found that x-ray quantity is approximately proportional to the square ratio of the applied voltage, thus:

$$\mathbf{I_{1/}I_2= (kvp_{1/}kvp_2)^2}$$

Where $I_1$is the intensity of the beam produced when kvp_1 voltage is applied on the tube and $I_2$is the intensity of the beam produced when kvp_2voltage is applied on the tube. Any change in the potential will affect both the amplitude and the position of the x-ray spectrum. The area under the curve increases with the square of the factor by which kvp is increased and the relative distribution of emitted x-ray photons shifts to the right (higher energies). Thus for the same mAs increase the applied voltage will increase x-ray beam quantity(Hanan, 2007).

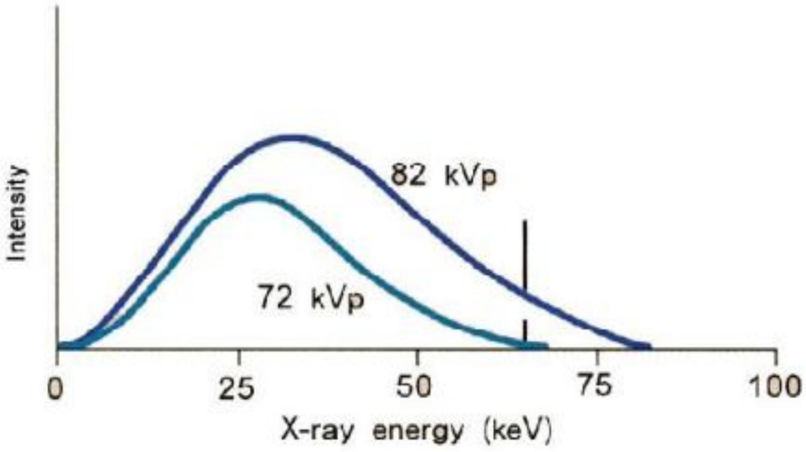


Figure (2.11): Effect of Tube potential on X-ray spectrum (Hanan, 2007)

Distance: The intensity of the x-ray is inversely proportional to the square distance from the target, thus:

$$\mathbf{I_1/I_2= (d_2/d_1)^2}$$

Where $I_1$is the intensity of the beam when a distance d_1 is used and I_2 is the intensity of the beam when a distance d_2 is used.

Filtration: any material that lies in the path of the x-ray beam is called filtration. There are two type of filtration: inherent and added filtration. The x-ray tube housing for example is an inherent filter material. Any added material to the beam is called added filtration. Filtration reduces the x-ray quantity by selectively removing low energy x-ray photons that do not add any information to the diagnostic image and hence improving the x-ray beam quality.

Thus the total effect of filtration on the x-ray beams:

-The minimum energy shifts towards higher energies.

-Change in the x-ray spectrum shape (figure 2.13)

-The peak of the spectrum shifts towards higher energies

-The maximum energy remain unchanged

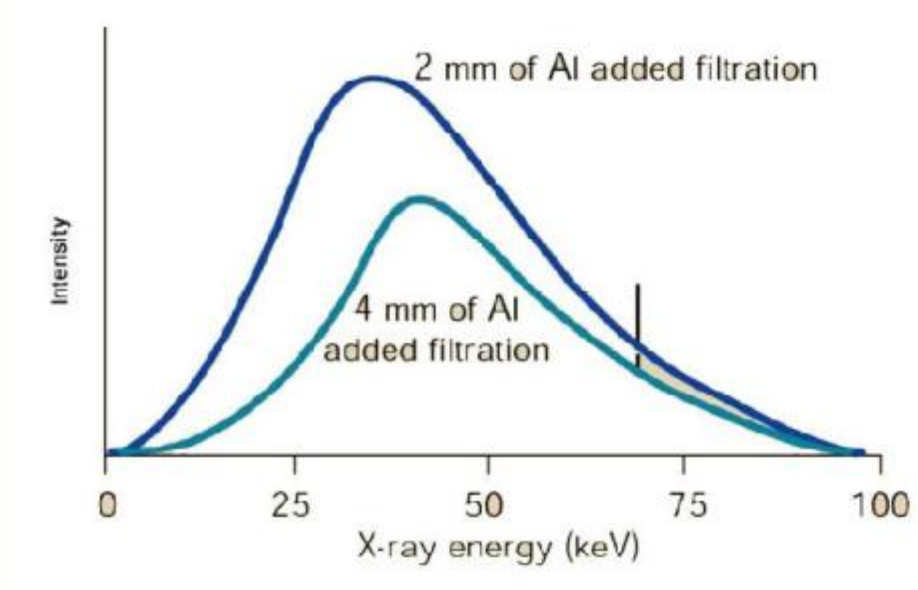


Figure (2.12) Effect of filtration on X-ray spectrum(Hanan, 2007)

2.6.2 X-ray beam quality:

The x-ray quality is a measure of the penetrating ability of the x-ray beam and it is measured by half value layer (HVL) of the beam. HVL is the thickness of a substance needed to reduce the intensity of the beam into half of its original value. The larger HVL, the higher the beam quality.

Applied voltage (kvp) the kvp controls the speed of the accelerated electrons and therefore controls the energy of the produced x-rays and the half value layer.

Target material: The atomic number of the target material affects both the number and the effective energy of the x-rays. When the atomic number of the target is increased, the spectrum is shifted to the right (figure 2.14)

Filtration: the increase of the total filtration will increase the beam quality by removing low energy photons(Hanan, 2007).

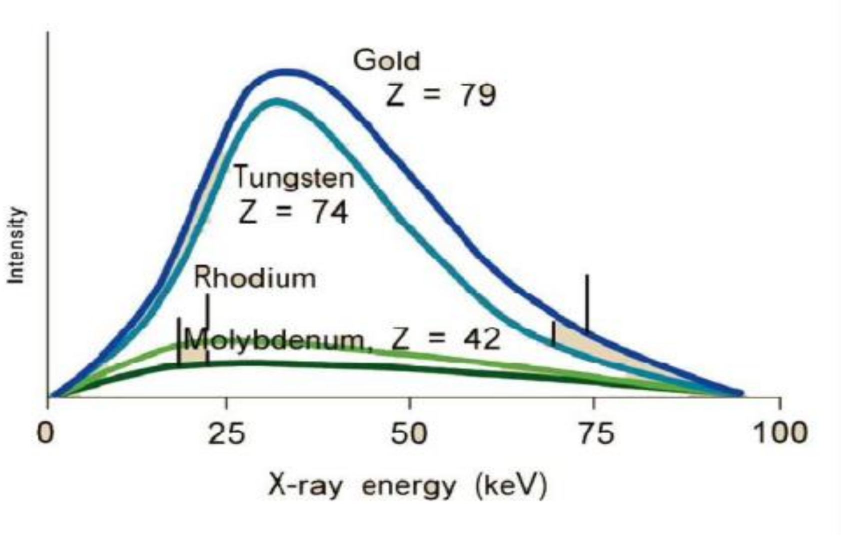


Figure (2.13): Effect of atomic number of target material on x-ray spectrum (Tungsten atomic number = 74, Molybdenum atomic number =42)(Hanan, 2007)

2.7 X-ray generator:

The principal function of an x-ray generator is to provide current at a high voltage to an x-ray tube. Electrical power aavailable to a hospital or clinic provides up to about 480 V, much lower than the 20.000 to 150.000 V needed for x-ray production. Transformers are principal components of x-ray generators: they convert low voltage into high voltage through a process called electromagnetic induction.

Electromagnetic induction is a phenomenon in which a changing magnetic field induces an electrical potential difference (voltage) in a nearby conductor and also in which a voltage is induced in a conductor moving through a stationary magnetic field. As the magnet moves in the opposite direction away from the wire, the induced current flows in the opposite direction. The magnitude of the induced voltage is proportional to the rate of change of the magnetic field strength.

Electrical current, such as the electrons flowing through a wire, produces a magnetic field whose magnitude (strength) is proportional to the magnitude of the current(Hanan, 2007).

2.8 Radiation biological effects:

The human body consists of tissues and organs. These tissues and organs are composed of cells which consist of molecules and other biological materials.

The molecules are a combination of atoms. The cell is composed mainly of nucleus, a surrounding liquid known as cytoplasm and a membrane which forms the cell wall. The cytoplasm is the factory of the cell while the nucleus contains all the information which the cell needs to carry out its function and reproduce itself. The nucleus contains the chromosomes which are small thread like structures made of genes. Then genes consist of deoxyribonucleic acid (DNA) and protein molecules and carry the information, which determines the characteristics of the daughter cell. Radiation may cause changes in complex molecular systems, such as living cells, in two ways direct interaction with the DNA in the cells and indirect interaction where the radiation may interact with other atoms or molecules in the cell (particularly water) to produce free radicals biologic effects radiation exposure can be classified as either stochastic or deterministic effect (sami, 2015).

2.9.1 A stochastic effect:

A stochastic effect is one in which the probability of the effect, rather than its severity, increases with dose. Radiation induced cancer and genetic effects are stochastic in nature. For example, the probability of radiation induced leukemia is substantially greater after an exposure to 1 Gy (100 rad) than to 0.01 Gy (1 rad), but there will be no difference in the severity of the disease if it occurs. Stochastic effects are believed not to have a dose threshold, because injury to a few cells or even a single cell could theoretically result in production of the disease (sami, 2015).

2.9.2 Deterministic effect:

If a radiation exposure is very high, the predominate biologic effect is cell killing that results in degenerative changes in the exposed tissue. In this case, the severity of the injury, rather than its probability of occurrence, increases with dose. These so-called deterministic effects differ from stochastic effects in that they require much higher doses to produce an effect. There is also a threshold dose below which the effect is not seen. Cataracts, erythema, fibrosis, and hematopoietic damage are some of the deterministic effects that can result from large radiation exposures (sami, 2015).

2.9.3 Somatic effects:

Somatic effects are harm that exposed individuals suffer during their lifetime, such as radiation induced cancers (carcinogenesis), sterility, pacification of the eye lens and life shortening (sami, 2015).

2.9.4 Genetic effects:

Genetic or hereditary effects are radiation induced mutations to an individual's genes and DNA that can contribute to the birth of defective descendants (sami, 2015).

2.10 Protection of the patient in diagnostic radiology:

Many of early pioneers in dental radiography suffered from adverse effects of ionizing radiation. The role of the dental radiographer is to achieve a high protection to the patient before, during and after exposure to x-rays (International Commission On Radiation Protection, 1990).

An important goal in diagnostic imaging is to achieve an optimal balance between image quality and dose to the patient.

Increasing the kvp will result in a greater transmission (and therefore less absorption) of x-rays through the patient. Even though the exposure per mAs increase as the kvp is increased, an accompanying reduction in the mAs will decrease the incident exposure to the patient. Unfortunately, there is a concomitant reduction in image contrast due to the higher effective energy of the x-ray beam. Within limits, this compromise is acceptable. Therefore, the patient exposure can be reduced by using higher kvp and lower mAs. Filtration of the polychromatic x-ray energy spectrum can significantly reduced exposure by selectively attenuating the low energy x-ray in the beam that would otherwise be absorbed in the patient with little or no contribution to image formation. This low energy x-ray mainly impart dose to the skin and shallow tissues where the beam enters the patient. As the tube flirtation is increased, the beam becomes hardened i.e. the effective energy increases and the dose to the patient decreases because fewer low energy photons are in the incident beam.

Increasing the source to object distance (SOD) and the source to image distance (SID) help reduce dose. As the SOD and SID are increased, a reduced beam divergence limits the volume of the patient being irradiated, thereby reducing the integral dose. The exposure due to tube leakage is also reduced since the distance from the tube to the patient is increased, although this is only a minor consideration(Ernest, etal 2014).

2.10.1 Patient protection:

With the use of proper patient protection techniques, the amount of radiation received by the patient can be minimized. The first important step in reducing the amount of x-radiation a dental patient receives is the proper prescribing, of dental radiographs. There should be professional judgment to make decisions about the number, type, and frequency of dental radiographs(Ernest, etal 2014).

2.10.2 Operator protection:

The dental radiographer must use proper protection measures to avoid exposure to primary radiation,leakage radiation and scatter radiation. The dental radiographer should never expose to the primary beam and limit x-ray exposure is to maintain an adequate distance during exposure. The dental radiographer must stand at least 6 feet away from the x-ray tube head during x-ray exposure.when this distance is not possible, a protective barrier must be used(Ernest, et al 2014).

2.11 Method of measuring:

Protection skin and eyes of the patient is of particular importance during diagnostic imaging of the dental x-ray since evidence suggests that x-ray could cause direct damage to the skin and eye. Shielding during dental x-ray procedures is an effective way of reducing dose to the patient. Given the potential harmful effects associated with exposure to ionizing radiation it is important not just to provide shielding, but also to measure patient doses and reduce them where possible.

Radiation has been long known to be harmful to humans. The radiation exposure received in dental x-ray examinations is known to increase the risk of malignancy as well as, above a certain dose, the probability of skin damage and cataract.

The biological effect of radiation depends on the total energy of radiation absorbed dose and expressed in Gray (Gy).

If a patient is exposed to an x-ray beam, some x-ray photons will pass through the patient without any interaction, and therefore will produce no biological effects. Absorbed dose of radiation can be measured and/or calculated and form basic evaluation of the probability of radiation induced effects. In evaluating biological effects of radiation after a particular exposure of the body, further factors such as the varying sensitivity of different tissues and absorbed doses to different organs have to be taken into consideration.

In today's diagnostic radiology, there is growing concern about radiation exposure. This can be seen in the recommendations of the International Commission on Radiation Protection (ICRP) and many other National publications. All these recommendation advice that x-ray examination should be conducted using techniques that keep patients dose as low as compatible with the medical purposes of the examinations. In order to achieve this recommendation, it is necessary to understand the factors that affect the exposure and to be able to evaluate patient's doses.

Intensive studies in the field of patient dose were conducted in the United Kingdom (UK) these studies eventually lead to the introduction of the European Union Council Directive which made it compulsory that patients dose be measured in every hospital and that doses should be compare to reference dose levels established by the competent authorities.

The need for standardization of radiation exposure and guidance levels for various radiographic examinations has also been proposed by the International Atomic Energy Agency (IAEA) as a safety standard. The guidance levels by IAEA are based on UK and European studies. Several guidelines and dose reference levels were also published by number of Internationalorganizations and were recently summarized by ICRP.

These guidelines have stimulated worldwide interesting patient' doses and several major dose surveys have been conducted. Patient dose has often been described by the entrance skin dose (ESD) as measured in the center of the x-ray beam including backscatter radiation. Because of the simplicity of its measurement, ESD is considered widely as the index to be assessed and monitored.

ESD is measured directly using Thermo Luminescence Dosimeter (TLD) placed on the skin of the patient or indirectly from the measured of dose area product using a large area Transmission Ionization Chamber (TIC) placed between the patient and the x-ray tube. The use of TLD method in ESD assessment is a time consuming process.

TLD technique requires prolonged annealing and reading process, furthermore, the use of TLD technique requires special equipment's and through calibration facilities which may not be available in most x-ray departments. On the other hand TIC method does not provide direct measurement of skin dose and mathematical equations are needed to convert TIC reading into skin dose.

Because of the limitations associated with both TLD and TIC, several mathematical equations have been suggested to relate skin dose to the used exposure factors such as the applied mAs, focus to skin distance (FSD), filtration, output, and the applied kvp.

These equations provide an easy and more particle mean of estimating skin dose even before exposure. They also provide the easiest and technique can be employed in any kind of patient dose survey or audit. Despite the attractive nature of the calculation methods of patient dose, one should make sure that the used x-ray equipment has adequate QC protocol that ensures the accuracy of the measured exposure factors.

For the purpose of dose estimate, charts and monograms have been published. These monograms and charts allow skin dose to be determination graphically over the diagnostic range of kvp, source to skin distance SSD and filtration. The use of those monograms and charts may be difficult and time consuming. An easier approach is to develop a functional relation between skin dose and the radiographic parameters such as kvp, mAs, SSD and filtration. Such an equation would make skin dose estimation much easier and practical.

Although ESD may be sufficient for quality control measurements where the stability of the x-ray equipment is often of concern, the entrance dose is not sufficient for comparison or evaluation of actual patient dose and associated risk. If the risk involved in an x-ray examination is to be estimated, ESD is not sufficient and patient dose needs to be described by other quantity that is more directly related to radiation effect. At present, it is considered that radiation induced effect can be assessed by virtue of the radiation doses in different organs or tissues in the body. Such data (organ dose) cannot be measured directly in patients undergoing x-ray examination, and are difficult and time consuming to be obtained by experimental measurements using physical phantoms.

One way of estimating internal dose of a patient is the percentage depth dose method. Percentage depth dose (PDD) is defined as the ratio of the absorbed dose at a certain depth to the dose at a reference depth (usually skin dose).

Percentage depth dose is usually measured using a water phantom and ionization chamber. The dose is measured at the surface of the phantom and at various depthswithin the phantom. The percentage depth dose at various depths is then calculated. Patient’s organ dose is then calculated from the knowledge of the organ depth and the previously calculated percentage depth. Provided that sufficient information regarding the exposure technique and patient size are available, organ doses can be calculated to a reasonable approximation using Monte Carlo simulation or depth dose techniques(Ernest, etal 2014).

2.12 Calculation method of Entrance skin dose:

Measurement of ESD is usually required for a specific type of radiograph if deterministic effects are possible. Entrance surface dose can be measured directly on the patient with TLDs or can be derived from measurements of incidence absorbed dose (ID) by multiplying by the backscatter factor(Tuokyefelix, 2016)..

2.12.1 Determination of ESD from TLD measurements:

TLDs are considered as the gold standard for determination of the entrance surface dose in practice. Measurements are made with thermo-luminescent dosimeters, TLDs, attached to the patient or phantom at points where the x-ray beam inters the patient or phantom. TLDs are read in a standard manner and value read is used as an estimate of the ESD received by the patient. If correctly calibrated to measure air kerma free in air, the TLD should give a direct reading of the entrance surface dose, and no correction is needed for backscattered radiation or distance from the tube focus, (Ibrahim, 2007 and Chilton, Didcot, 1992).

2.12.2 Calculation of ESD from tube output data:

ESD may be calculated in practice by means of knowledge of the tube output. The relationship between x-ray nit current time product (mAs) and the air kerma free in air is established at a reference point in the x-ray field at 80 kvp tube potential. Subsequent estimates of the ESD can be done by recording the relevant parameters (tube potential, filtration,mAs and FSD) and correcting for distances and backscatter radiation according to the following equation:

$$ESD = OPx \left(\frac{kV}{80} \right)^2 xmAsx \left(\frac{100}{FSD} \right)^2 xBSF \qquad (2\text{-}1)$$

Where OP is the tube output per mAs measured at a distance of 100 cm from the tube focus along the beam axis at 80 kvp, kv is peak tube voltage (kvp) recorded For any given examination (in many cases the output is measured at 80 kvp, and therefor this appears in the equation as a quotient to convert the output into an estimate of that which would be expected at the operational kvp. The value of 80 kvp should be substituted with whateverkvp the actual output is recorded at in any given instance).

mAs is the tube current-time product which is used in any given instant. FSD is the focus to patient entrance surface distance and BSF is the backscatter factor.

The second trace of skin dose can be use formulas published by Tung and Tasi in 1999. Tung and Tasi studied the relationship between entrance skin dose and x-ray tube potential and between entrance skin dose and Aluminum filtration(Tuokyefelix, 2016)..

$$ESD = c\left(\frac{KVp}{FSD}\right)^2\left(\frac{mAs}{mm.Al}\right) \quad (2\text{-}2)$$

Where ESD stand for Entrance Skin Dose, c= constant=0.2775, kvp= applied tube potential,mAs=tube current multiplied by exposure time, FSD= focus to skin distance, AL=Aluminum filtration.

2.12.3 Calculation of ESAK and ESD from tube output data:

The relationship between x-ray unit current time product (mAs) and the air kerma free in air is established at a reference point in the x-ray field for the range of tube potentials encountered. Subsequent estimate of the entrance dose can be done by recording the relevant parameters (tube potential, filtration, mAs and FSD) and correcting for distances and backscattered radiation in case of ESD estimation as implied in the formula bellow (Ibrahim, 2007).

$$\mathbf{ESAK = K_{air}(100cm)(100/FSD)^2} \qquad (2\text{-}3)$$

$$\mathbf{ESD = ESAK.BSF} \qquad (2\text{-}4)$$

2.13 Previous studies:

-Ofri, etal (2013) found that the highest percentage dose of teeth region was molar following premolar and anterior teeth. According to the study was the most prominent error for the dose of teeth molar imaging, they found that the most common area get highest dose were the maxillary molar area followed by maxillary premolar area and mandibular molar area.

Protection skin and eyes of the patient is of particular importance during diagnostic imaging of the dental x-ray since evidence suggests that x-ray could cause direct damage to the skin and eye. Shielding during dental x-ray procedures is an effective way of reducing dose to the patient. Given the potential harmful effects associated with exposure to ionizing radiation it is important not just to provide shielding, but also to measure patient doses and reduce them where possible.

-S.M, JMortazavi et al (2004) found that the measured surface doses in the study exceed the doses reported by Diederichs et al (1996). However, as in Iran there is no national DRLs for orthopantomoghraphy, it is not clear whether in case of the OPG system used in this experiment, reducing the radiation dose to a level that still provides a diagnostically acceptable image quality is necessary. It can be concludes that an extended study should be conducted to assess if the radiation dose with the panoramic PM 2002 CC system could be reduced without significant impairment of the subjective image quality.

-M. Bekas, K.A. pachocki et al found that 69% fully meets the criteria set out in the polish legislation regarding the safe use of ionizing radiation in medicine, while 30.4% did not meet some of them.

A tenfold difference in the size of the dose received by patients during dental x-ray examination was discovered. For example, during radiography of the canine teeth of child, the recorded entrance skin dose (ESD) ranged from 72.8 to 2430 micro Gy with the average value of 689.1 micro Gy. Cases where the dose reference level defined in polish legislation of 5 mGy was exceeded were also found.

-E. HELMROT et al (2015) they found that exposure of patients undergoing periodical examinations, on average, do not exceed the dose reference levels specific in the standers (7 mGy), in some cases if these levels (10.6 +- 0.7 mGy and 9.2+- 1.4 mGy) for left and right first molar teeth respectively these levels were exceeded.

It was learned that it is necessary to do quality control to those X-ray systems that exceeded the limit.

CHAPTER THREE

Material and Methods

CHAPTER THREE

Material and methods

3.1 Patient data:

The patient anthropometrical data (age and gender) and technical parameter (kv,mA,S,FSD) used were collected at the time of the examination.

3.2 Equipment:

Dental x-ray machine was used in these study namely Vatech D-081B Toshiba in Khartoum Dental Educational Hospital.

3.3 Method and measurement:

The ESD is defined as theabsorbed dose measured in air on the x-ray beam axis at the point where the x-raybeam enters the patient.
Dose calculation is a software system designed to calculate and report entrance surface dose manually the tube output data and exposure factors entered. The exposure factors were fed in excel program and then the mean, standard and also minimum and maximum values for kV, mAs, age were decided (in tables). The ESD was calculated in the present work using the following relation:

$$ESD = OPx \left(\frac{kV}{80}\right)^2 xmAsx \left(\frac{100}{FSD}\right)^2 xBSF$$

Where (OP) is the tube output per mAs measured at a distance of 100 cm from thetube focus along the beam axis, kV is peak tube voltage recorded for any given examination, mAs is the tube current and time product, FSD is the focus-to-patiententrance surface distance and BSF is the backscatter factor, ESD values weremeasured by using the equation.

The equation used in this study was specially developed for the evaluation of ESD dose,It is based by which by patient doses can bedetermined from exposure factors recorded at the time of the examination.

The output in mGy/mAs in dental X-rays machines, used for dose evaluation. Once the tube potential, tubecurrent, exposure time, FDD and FSD were determined, ESD was calculatedby equation above.

The kV and mAs was changed according to the type of examination and patient age.The data was analyzed using excel program and then the tables were created in chapter four.

3.4 Duration of the study:

Three months.

3.5 Area of the study:

Khartoum Dental Educational Hospital

CHAPTER FOUR

RESULTS

CHAPTER FOUR

RESULTS

4.1The community of the study sample:

Means the community college study group of elements that the study is seeking to circulate them related to the problem studied the results. The original study population consists Khartoum dental educational hospital.

The study sample was randomly selected from the study population, where the researcher distributed number (200) on the Evaluation of Entrance Skin Dose in the periodical Dental X-ray examination, and responded (200)divided into eight parts (100 respondents represent the upper divided into central incisor, canine, premolar and molar and100 respondents represent the lower divided into central incisor, canine, premolar and molar).

Table No. (1)shows the age

Measures	Upper				Lower			
	Central incisor	Canine	Premolar	Molar	Central incisor	Canine	Premolar	Molar
Mean	30.12	31.6	33.32	33.48	12.48	34.1	29.64	27.28
St.deviation	15.54	14.52	17.9	16.3	12.11	21.76	22.11	15.65

Figure No. (1)Shows the age

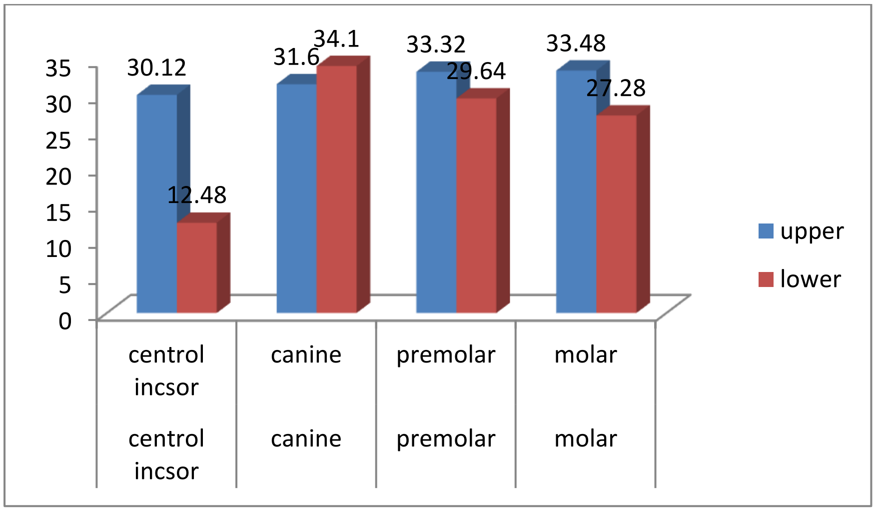


Table No. (2)Shows the gender

Gender	upper				Lower			
	Central incisor	Canine	premolar	Molar	Central incisor	Canine	Premolar	Molar
Male	12 %48.0	12 %48.0	11 %44.0	13 %52.0	14 %56.0	10 %40.0	15 %60.0	7 %28.0
Female	13 %52.0	13 %52.0	14 %56.0	12 %48.0	11 %44.0	15 %60.0	10 %40.0	18 %72.0

Figure No (2)Shows the gender (male)

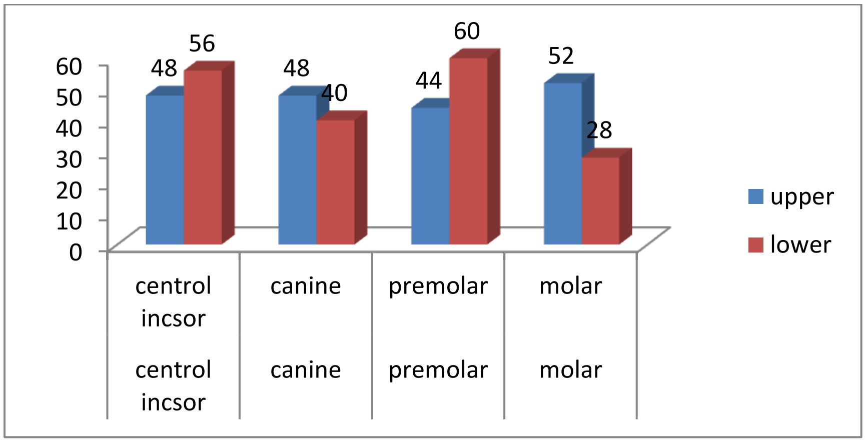


Figure No (3)shows the gender (female)

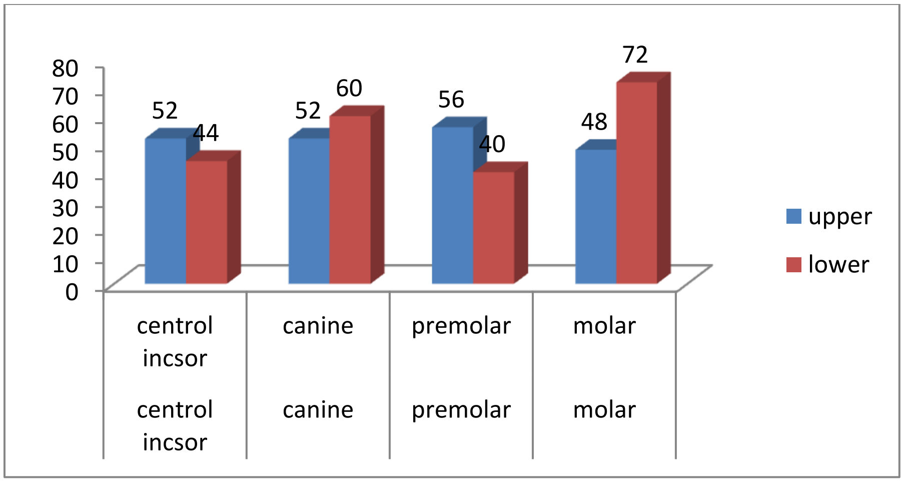


Table No. (3)Shows the KV

Measures	upper				Lower			
	Central incisor	Canine	Premolar	Molar	Central incisor	Canine	Premolar	Molar
Mean	65	65	65	65	65	65	65	65
St.deviation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Figure No. (4)Shows theKV

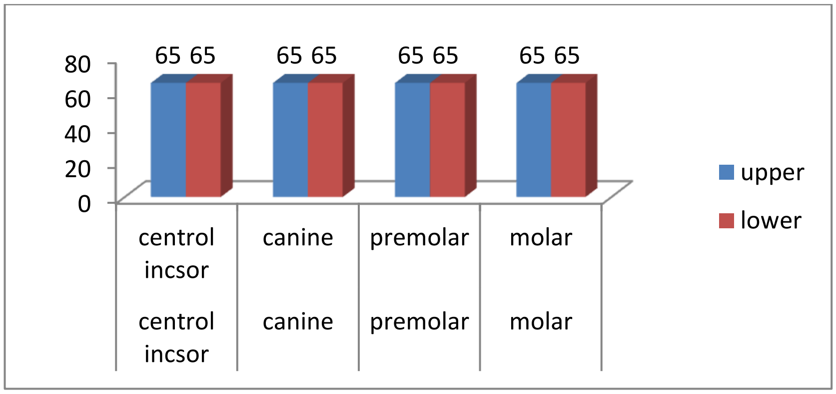


Table No. (4)shows the mA

Measures	upper				Lower			
	Central incisor	Canine	Premolar	Molar	Central incisor	Canine	Premolar	molar
Mean	5	5	5	5	5	5	5	5
St.deviation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Figure No. (5)Shows the mA

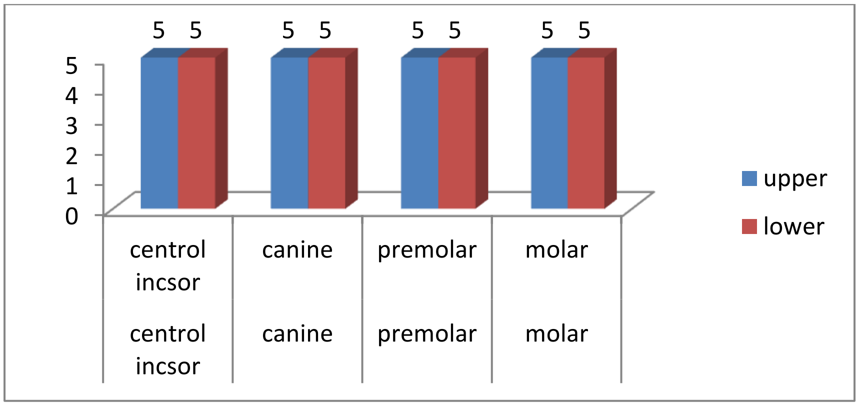


Table No. (5)shows the S (second)

Measures	upper				Lower			
	Central incisor	Canine	Premolar	Molar	Central incisor	Canine	Premolar	Molar
Mean	0.20	0.20	0.30	0.250	0.150	0.150	0.20	0.40
St.deviation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Figure No. (6)shows theS (second)

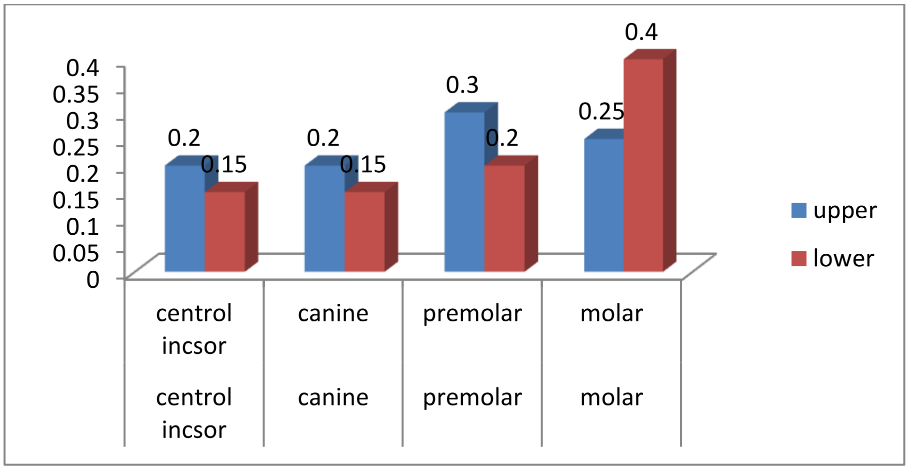


Table No. (6)shows the mAs

Measures	upper				Lower			
	Central incisor	Canine	Premolar	Molar	Central incisor	Canine	Premolar	Molar
Mean	1.0	1.0	1.50	1.25	0.75	0.75	1.0	2.0
St.deviation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Figure No. (7)shows themAs

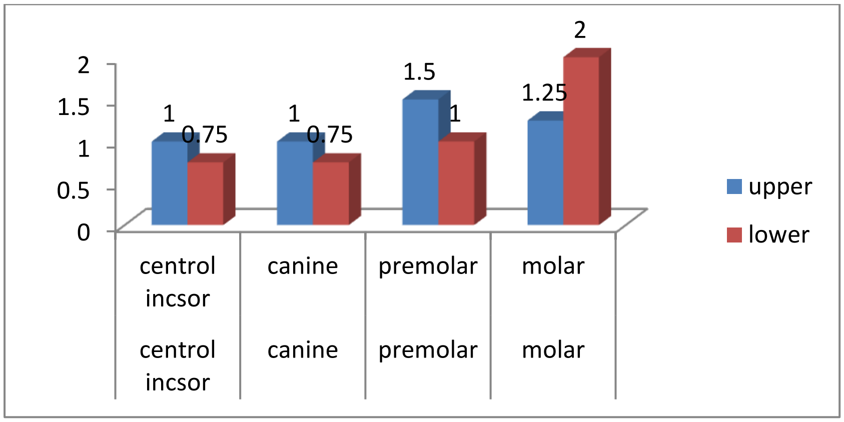


Table No. (7)shows the AL filter (Aluminum filter)

Measures	upper				Lower			
	Central incisor	Canine	Premolar	Molar	Central incisor	Canine	Premolar	Molar
Mean	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
St.deviation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Figure No. (8)shows theAL filter (Aluminum filter)

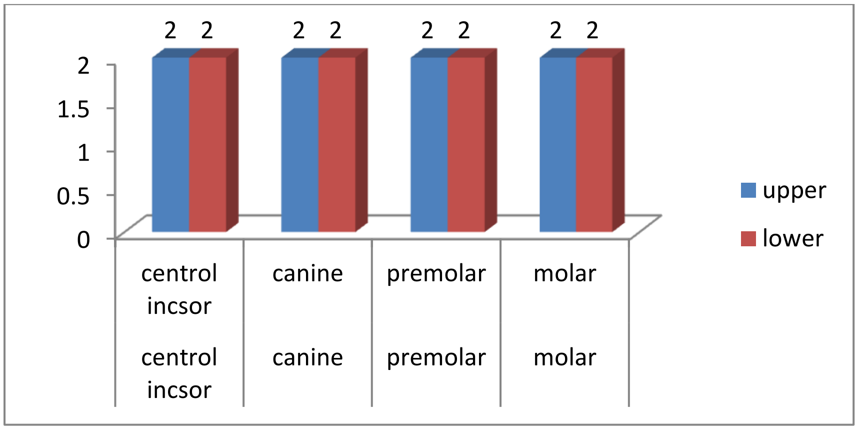


Table No. (8)shows the SSD

Measures	upper				Lower			
	Central incisor	Canine	Premolar	Molar	Central incisor	Canine	Premolar	Molar
Mean	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0
St.deviation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Figure No. (9)shows the SSD

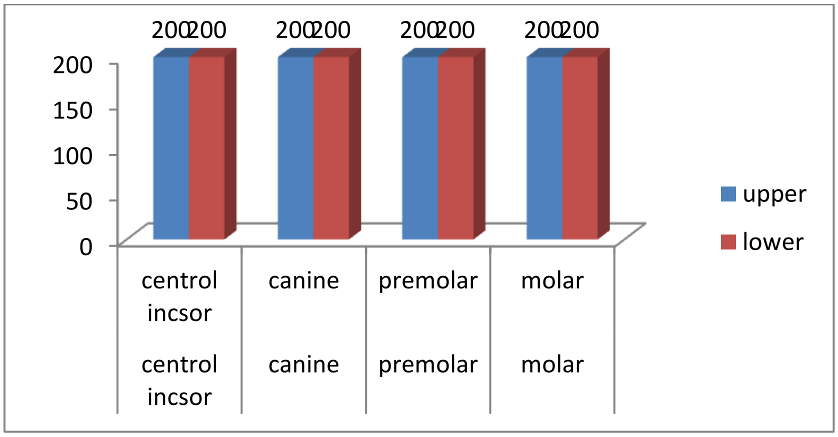


Table No. (9)shows the C (constant)

Measures	upper				Lower			
	Central incisor	Canine	Premolar	Molar	Central incisor	Canine	Premolar	Molar
Mean	0.2775	0.2775	0.2775	0.2775	0.2775	0.2775	0.2775	0.2775
St.deviation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Figure No. (10)shows the C (constant)

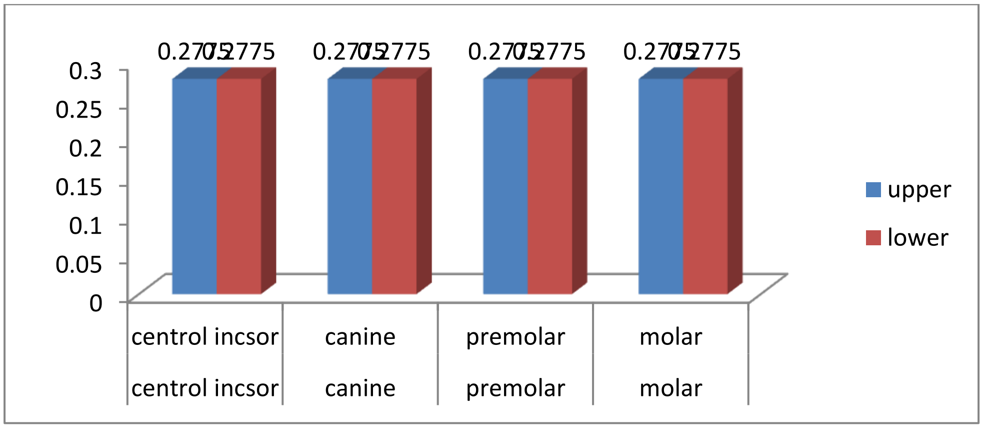


Table No. (10)shows the ESD

Measures	upper				Lower			
	Central incisor	Canine	Premolar	Molar	Central incisor	Canine	Premolar	Molar
Mean	0.0147	0.0147	0.0220	0.0183	0.0110	0.0110	0.0146	0.0293
St.deviation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Figure No. (11)shows the ESD

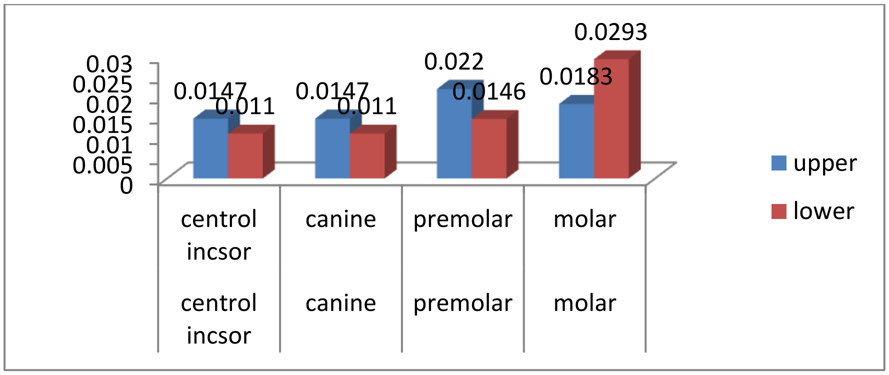


Table no. (11) shows the probability values of the test

	Central incisor	Canine	Premolar	Molar
Age	0.000	0.638	0.000	0.405
Gender	1.000	0.578	0.267	0.086
KV	-	-	-	-
MA	-	-	-	-
S	0.000	0.000	0.000	0.000
MAS	-	-	-	-
AI filter	-	-	-	-
SSD	-	-	-	-
C	-	-	-	-
ESD	0.000	0.000	0.000	0.000

1. Correlations between the (age) and (ESD):

Table no. (12) shows the values of correlation

Measure	upper				Lower			
	Central incisor	Canine	Premolar	Molar	Central incisor	Canine	Premolar	Molar
Correlation between age and ESD	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

CHAPTER FIVE

5.1Discussion:

-The original study population consists Khartoum Dental Educational Hospital
The study sample was randomly selected from the study population, where the researcher distributed number (200) questionnaire on the Evaluation of Entrance Skin Dose in the periodical Dental X-ray examination, and responded (200)divided into eight parts (100 respondents represent the upper divided into central incisor, canine, premolar and molar and100 respondents represent the lower divided into central incisor, canine, premolar and molar)individuals representing any (100%) almost from the target, where the returned questionnaires filled in all the required information.

- From Table (1) and Figure No. (1)That the highest mean of age belongs to the lower sample (canine) of the study is (34.1) and the highest standard deviation belongs to the lower sample (premolar).

- From Table (2) and figure (2) that the highestnumber of male belongs to the lower sample (Premolar) of the study with (60.0%) and the highest number of female belongs to the lower sample (canine) with (60.0%).

- From Table (3) and figure (3) that the mean of kv is equal for both upper and lower (65) and standard deviation is equal for both upper and lower (0.00).

-From Table (4) and figure (4) that the mean of mA is equal for both upper and lower (5) and standard deviation is equal for both upper and lower (0.00).

- From Table (5) and figure (5) that the highest mean of second belongs to the lower sample (molar) of the study is (0.40) and standard deviation is equal for both upper and lowers (0.00).

- From Table (6) and figure (6) that the highest mean of mAs belongs to the upper sample (premolar) of the study is (1.50) and standard deviation is equal for both upper and lowers (0.00).

- From Table (7) and figure (7) that the mean of AL filter is equal for both upper and lower (2.0) and the standard deviation is equal for both upper and lower (0.00).

- From Table (8) and figure (8) that mean of SSD is equal for both upper and lower (200.0) and the standard deviation is equal for both upper and lower (0.00).

- From Table (9) and figure (9) that mean of constant is equal for both upper and lower (0.2775) and the standard deviation is equal for both upper and lower (0.00).

- From Table (10) and figure (10) that the highest mean of ESD belongs to the lower sample (molar) of the study is (0.0293) and the standard deviation is equal for both upper and lowers (0.00).

- Test the first hypothesis: (there is no significant difference between variables in upper and lower)
-From table (11) we note the following points:

-As for the age: there is significant difference in just central incisor and Premolar between upper and lower because p-value (0.000) is less than (0.05).
-As for the gender: all p-values more than (0.05) that's mean there is no significant difference between upper and lower for all variables.
-As for the (KV, mA, mAS, AL filter, SSD and C): we cannot calculate p-values because the standard deviations equal (0), that's mean there is no significance difference between upper and lower for all variables.
-As for the (S): there is significant difference between upper and lower for all variables because p-value (0.000) is less than (0.05).
-As for the (ESD): there is significant difference between upper and lower for all variables because p-value (0.000) is less than (0.05).
- It's clear from table (11) that all the correlation values equal (0.000).that is mean, there is no relationship between age and ESD for both upper and lower.

5.2 Conclusion:

Entrance surface dose were estimated in the present study for patients undergoing selected dental X-ray examination in Khartoum dental educational hospital.

The mean of ESD values of upper and lower jaw in the hospital respectively (0.017425, 0.016475 mGy) less than reference levels recommended by ICRP (1.2 mGy), and no different in dose between the upper and the lower jaw.

5.3 Recommendations:

-Diagnostic radiology should be governed with high professional's techniques to minimize radiation hazard on patient while they are examined by dental X-ray**.**
- Dose to the patient should be at the lowest level that still guarantees asufficient diagnostic image quality.

- Patient dose should be deal with thickness of the jaw.

References:

-Alcox, 1978: Biological Effects and Radiation Protection in the Dental Office, Dent Clin North Am 22:517.

-Council on Dental Material, Instruments, and Equipment: Recommendation in Radiographic Practice: an update, 1988, JADA 118:115, 1989.

-International Commission on Radiation Protection: Radiation Protection, ICRP Publ. 60, Oxford, 1990, Author. Blackwell Scientific, Oxford.

-Assessment of Radiation risk from dental radiography. Dentomaxillofac. Radiol, 21: 118-26.

-International Commission on Radiological Protection. Radiological Protection and Safety in Medicine ICRP Publication 73.Annals of the ICRP 26, No 2(Pergamon Press, Oxford).

-International Commission on Radiological Protection. Diagnostic Reference Levels on Medical imaging: Review and Additional Advice (A web module produced by committee 3 of the ICRP).

-Optimization and Guidance levels for Radiation Protection in Diagnostic X-ray Examination. JMAJ, 44: 480-483.

-Williams J.R. and Montgomery A. (2000). Measurement of dose in panoramic dental radiology .The British Journal of Radiology; 73: 1002-1006.

-Bushberg, J.T., Seibert J. A., Leidhold E.M. and Bone J.M.(2012): The Essentials of Medical Imaging 3nd Edition Lippincott williams&wilkins,philadephia.

-E. B. Podgorsak ; IAEA 2005 AustriaRadiation oncology physics : a handbook forteachers and students.

-Hanan Fawaz Akhdar (2007) assessment of entrance skin dose and effective doseof some routine x-ray examinations using calculation technique. Masters thesis, King Saud University.

-Ibrahim Idris Suliman (2007) Patient Dosimetry and Quality Control in Diagnostic Radiology- Sudan Academy of Sciences (SAS).

-Sami Nasreldeen Abdelwally Eljak (2015) Evaluation of Entrance Skin Radiation Exposure Dose for Pediatrics Examined by Digital Radiography.

-Tuokyefelix (2016) measurement of entrance surface dose with the female anthropomorphic phantom on selected diagnostic examination using thermo luminescence dosimeter, medical physics Ghanauniversity.

Appendix

Machine image

Image 1

Image 2


vatech
65kVp 5mA D-081B Toshiba
0.8mm IEC 336
2.0mm Al
(0.8mm Al)
ESX

Image 3