بسم الله الرحمن الرحيم

و به نستعين

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College of Medical Radiological Science
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Assessment of Radiation Dose Received by Thyroid Gland during OPG Examinations.

تقويم الجرعة الأشعاعية للغدة الدرقية أثناء التصوير الطبقي للفكين

A thesis submitted for partial fulfillment of the requirements for BSc degree in diagnostic radiologic technology.

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الآية

قال تعالى :

قُل لَّوْ كَانَ الْبَحْرُ مِدَادًا لِّكَلِمَاتِ رَبِّي لَنَفِدَ الْبَحْرُ قَبْلَ أَن تَنفَدَ كَلِمَاتُ رَبِّي وَلَوْ جِئْنَا بِمِثْلِهِ مَدَدًا

صدق الله العظيم

سورة الكهف (109)

Dedication

To:

Our parents for their patience and encouragement.

We dedicate the benefits of this humble work to our teachers and supervisor.

Our senior gratitude students and dedications are also extended to our colleagues and friends to their support, great motivation and encouragement during this research.

Acknowledgment

We would like to thank God for everything and our supervisor Ass.Prof. Mahmoud Mohammed Hamed for his support and hard work and for his patience to let this work see the light.

Also we are deeply grateful to Khartoum Dental Hospital for their collaboration and encouragement.

Abstract

This study was conducted to assess the thyroid gland dose for the patients during Roth pan tomography (OPG) examination , The data were collected within one month from August 2015 to September 2015 in Khartoum dental hospital , only adult patients ≥18 years were involved in the study, All pregnant and infant patients were excluded from the study. A dental panoramic **Planmeca/Proline XC** machine was used in our study. The aim of the study carried out. to measure patient dose. And to know the relation between the ESD of the thyroid and Kvp, Mas, age, BMI. The result related that there is direct relationship between thyroid dose and Kvp and mAs , every increase in the Kvp or the mAs will increase the ESD to the gland also thyroid gland dose with BMI of patient will increase the ESD with every increase in the unit of the BMI .

The mean ± standard deviation of ESD calculated was (3.397±0.4139).

مخلص الدراسة

أجريت هذه الدراسه لتقدير الجرعه الاأشعاعيه للغده الدرقية للمريض أثناء فحص الأسنان الكامل للفكين العلوي والسفلي , تم الحصول على البيانات المستخدمة في هذه الدراسة من مستشفى الخرطوم للأسنان وتم جمعها في كراسة البيانات في الفترة من اغسطس 2015 الى سبتمبر 2015, والهدف الذي أعدت من اجله الدراسه هو تقدير الجرعة الأشعاعيه للغدة الدرقية أثناء فحص الأسنان الكامل للفكين العلوي والسفلي , ومن هذه الدراسة تم الحصول على نتائج اثبتت أن هناك علاقة بين فرق الجهد المطبق في جهاز البانوراما والجرعة الأشعاعية الممتصة في الغدة الدرقية للمريض وتزيد بزيادة فرق الجهد المطبق وكذلك أوضحت النتائج أنه كل ما زاد حجم المريض تزيد الجرعة الأشعاعية الممتصة لأنه كلما زاد حجم المريض تقتضي الحوجة لي زيادة فرق الجهد المطبق للحصول على صورة يمكن من خلالها تشخيص المرض وبالتالي تزيد الجرعة نسبة لزيادة فرق الجهد ولوحظت من النتائج أن اختلاف أعمار المرضى لا يساهم في زيادة أو نقصان الجرعه الأشعاعيه الوسيط $\pm$ الانحراف المعياري (3.397±0.4139) للغدة الدرقية .

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List of abbreviations

ALARA	As Low As Reasonable Achievable
BMI	Body Mass Index
BSF	Back Scatter Factor
CBCT	Cone Beam Computerized Tomography
DAP	Dose Area Product
ESAK	Entrance Surface Air Kerma
ESD	Entrance Surface Dose
FSD	Focus Skin Distance
Gy	Gray
IAEA	International Atomic Energy Agency
ICRP	International Commission Radiation Protection
KERMA	Kinetic Energy Released Per unite mass
Kev	Kilo Electron Volt
Kg	Kilogram
Kv	Kilo Volte
LET	Linear Energy Transfer
Mas	mille-Amber second
NRPB	National Radiological Protection Board
OP	Out Put
OPG	Ortho pan tomography
RAD	Radiation Absorbed Dose
REM	Roentgen Equivalent Man
Sv	Sievert
TLD	Thermo Luminescence Dosimeter
WT_R	Weighting Tissue Factor

Chapter one

Introduction

Chapter one

1.1 Introduction

Orthopan tomography is a well-established imaging technique in dental diagnosis. Although its exposure to individuals is relatively low compared to other diagnostic radiology examinations, it is still the most frequent X-ray examination. So it is important to estimate absorbed dose to critical organs in this examination specially the thyroid gland .The anatomic position and proven radio sensitivity of the thyroid make it an organ of concern in dental X-ray examinations . the radiation dose in panoramic radiographies could be reduced without significant impairment of the subjective image quality, It is well-known that critical organs such as thyroid gland are exposed to X-rays in panoramic radiography and these exposures should be kept as little as reasonably achievable. To perform quality assurance and optimize the relationship between radiation dose and image quality, accurate dose measurements in diagnostic radiology procedures are necessary.

1.1.1 Dental Radiographs

Dental Radiographs commonly called X-Rays. Dentists use radiographs for many reasons: to find hidden dental structures, malignant or benign masses, bone loss, and cavities. The dosage of X-Ray radiation received by patient during dental radiography typically small around 0.150 mSv for a full mouth series, according to the American Dental Association website.

Incidental exposure further reduced by the use of a lead shield, lead apron, sometimes with a lead thyroid collar. Technician exposure reduced by stepping out of the room, or behind adequate shielding material, when the X-Ray source activated.

1.1.2 Types of dental radiographic techniques:

There are two main types of dental X-rays: intraoral (meaning the X-ray film is inside the mouth) and extra oral (meaning the X-ray film is outside the mouth).

1- Intraoral X-rays are the most common type of X-ray taken. You've probably had many sets of these X-rays taken in your life already.

   These X-rays provide a lot of detail and allow your dentist to find caries, check the health of the tooth root and bone surrounding the tooth, check the status of 3developing teeth, and monitor the general health of your teeth and jawbone.

2- Extra oral X-rays show teeth, but their main focus is the jaw and skull. These X-rays do not provide the detail found with intraoral X-rays and therefore are not used for detecting caries or for identifying problems with individual teeth. Instead, extra oral X-rays are used to look for impacted teeth, monitor growth and development of the jaws in relation to the teeth, and to identify potential problems between teeth and jaw and the temporomandibular joint (TMJ) or other bones of the face. (See the document, "Temporomandibular Disorders" for more information.)

The technique uses less radiation than the typical X-ray and there is no wait time for the X-rays to develop. The images are available on a screen a few seconds after being taken. The image taken, of a tooth for example, can be enhanced and enlarged many times it's actual size on the computer screen, making it easier for your dentist to show you where and what the problem is .Images can be electronically sent to another dentist or specialist – for instance, for a second opinion on a dental problem to determine if a specialist is needed. The images can also be sent to a new dentist (for example, if you move). Software added to the computer can help dentists digitally compare current to previous images in a process called subtraction radiography. Using this technique, everything that is the same between two images is "subtracted out" from the image, leaving a clear image of only the portion that is different. This helps dentists easily see the tiniest changes that might not have been noticed by the naked eye.

1.2 Problems of the study:

Patients were exposed to significant radiation doses during “OPG” examinations. This investigation were subjected to repetition during patients management more than one time Due to this irradiation , the radiosensitive organs (thyroid gland) were exposed to high dose with imposes a radiation risk to the patients .

1.3 Objectives:

1.3.1 General objective:

Assessment of Radiation Dose Received by Thyroid gland During Ortho-Pan-Tomography “OPG” examinations

1.3.2 Specific objectives:

1. To calculate patient dose during Ortho-Pan-Tomography and ESD for thyroid.
2. To correlate between thyroid dose, Kvp and mAs
3. To correlate between thyroid dose, Body Mass Index

1.4 Over view of the study:

Chapter 1 deals with introduction, Chapter 2 deals with theoretical background, Chapter 3 deals with Material and method, Chapter 4 deals with Results, Chapter 5 deals with Discussion ,conclusion, recommendations and references.

Chapter Two

Theoretical background

CHAPTER TWO

2.1 Theoretical Background:

2.1.1 Anatomy of the Thyroid Gland

The thyroid gland or simply the thyroid is one of the largest endocrine glands in the body, and consists of two connected lobes. It is found in the neck, below the laryngeal prominence (Adam's apple). The thyroid gland controls how quickly the body uses energy, makes proteins, and controls the body's sensitivity to other hormones. It participates in these processes by producing thyroid hormones, the principal ones being thyroxine (T_4) and triiodothyronine (T_3), which is more active. These hormones regulate the growth and rate of function of many other systems in the thyroid gland, is one of the largest endocrine glands in the body, and consists of two connected lobes. It is found in the neck, below the laryngeal prominence (Adam's apple). The thyroid gland controls how quickly the body uses energy, makes proteins, and controls the body's sensitivity to other hormones. It participates in these processes by producing thyroid hormones, the principal ones being thyroxine (T4) and triiodothyronine (T3), which is more active. These hormones regulate the growth and rate of function of many other systems in the body. T3 and T4 are synthesized from iodine and tyrosine. The thyroid also produces calcitonin, which plays a role in calcium homeostasis.

Hormonal output from the thyroid is regulated by thyroid-stimulating hormone (TSH) produced by the anterior pituitary, which itself is regulated by thyrotropin-releasing hormone (TRH) produced by the hypothalamus.

https://en.wikipedia.org/wiki/Thyroid

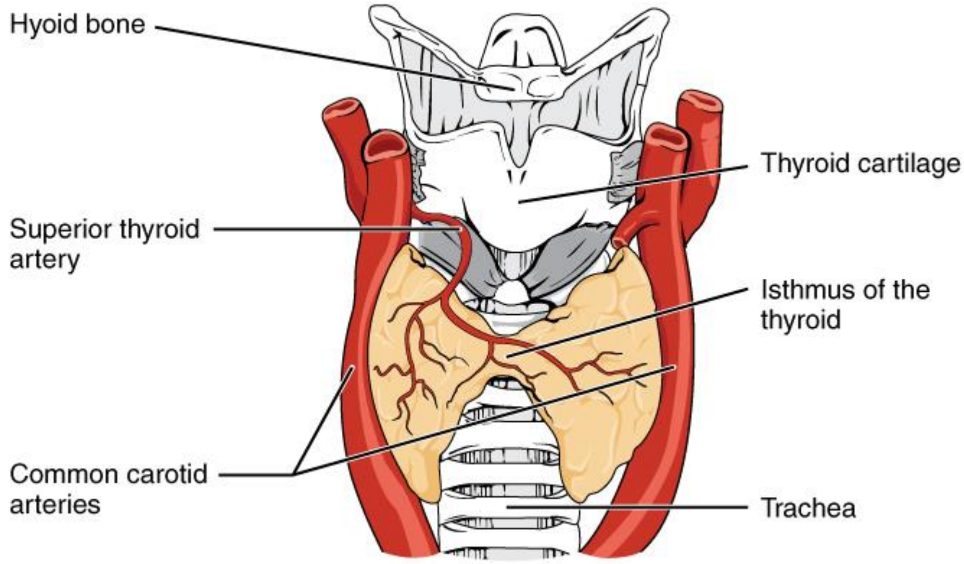

Figure 2.1 the human thyroid as viewed from the front, with arteries visible

2.1.2 Physiology

The primary function of the thyroid is production of the hormones T3, T4 and calcitonin. Up to 80% of the T4 is converted to T3 by organs such as the liver, kidney and spleen. T3 is several times more powerful than T4, which is largely a prohormone, perhaps four or even ten times more active

T_3 and T_4 production and action

Thyroxine (T_4) is synthesized by the follicular cells from free tyrosine and on the tyrosine residues of the protein called thyroglobulin (Tg). Iodine is captured with the "iodine trap" by the hydrogen peroxide generated by the enzyme thyroid peroxidase (TPO) and linked to the 3' and 5' sites of the benzene ring of the tyrosine residues on Tg, and on free tyrosine. Upon stimulation by the thyroid-stimulating hormone (TSH), the follicular cells reabsorb Tg and cleave the iodinated tyrosine's from Tg in lysosomes, forming T_4 and T_3 (in T_3, one iodine atom is absent compared to T_4), and releasing them into the blood. Deiodinase enzymes convert T_4 to T_3.

Thyroid hormone secreted from the gland is about 80-90% T_4 and about 10-20% T_3.

Cells of the developing brain are a major target for the thyroid hormones T_3 and T_4. Thyroid hormones play a particularly crucial role in brain maturation during fetal development. A transport protein that seems to be important for T_4 transport across the blood–brain barrier (OATP1C1) has been identified. A second transport protein (MCT8) is important for T_3 transport across brain cell membranes.

Non-genomic actions of T_4 are those that are not initiated by liganding of the hormone to intranuclear thyroid receptor. These may begin at the plasma membrane or within cytoplasm. Plasma membrane-initiated actions begin at a receptor on the integrin alphaV, beta3 that activates ERK1/2. This binding culminates in local membrane actions on ion transport systems such as the Na^+/H^+ exchanger or complex cellular events including cell proliferation. These integrins are concentrated on cells of the vasculature and on some types of tumor cells, which in part explains the proangiogenic effects of iodothyronines and proliferative actions of thyroid hormone on some cancers including gliomas. T_4 also acts on the mitochondrial genome via imported isoforms of nuclear thyroid receptors to affect several mitochondrial transcription factors. Regulation of actin polymerization by T_4 is critical to cell migration in neurons and glial cells and is important to brain development

The parathyroid glands make parathyroid hormone. PTH regulates the calcium level in the blood. . **[3]**

Regulation of blood calcium level

PTH and calcitonin interact to maintain the calcium level within a narrow range.

PTH acts to increase blood levels of calcium.

- When the blood calcium level falls below a certain level, the parathyroid glands secrete PTH, which stimulates osteoclasts to break down bone and release calcium into the blood.
- PTH also acts on the kidneys and intestines to make them absorb more calcium, rather than release it. Calcitonin acts to decrease blood levels of calcium.
- When the blood calcium level rises above a certain point, the thyroid secretes calcitonin, which causes calcium to be deposited in the bones. **[3]**

2.1.3 X-Ray tube:

X-rays can be generated by an X-ray tube, a vacuum tube that uses a high voltage to accelerate the electrons released by a hot cathode to a high velocity. The high velocity electrons collide with a metal target, the anode, creating the X-rays.(Roobottom CA, Mitchell G, Morgan-Hughes G2010. Radiation-reduction strategies in cardiac computed tomography angiography). Clin Radial65) In medical X-ray tubes the target is usually tungsten or a more crack-resistant alloy of rhenium (5%) and tungsten (95%), but sometimes molybdenum for more specialized applications, such as when soft X-rays are needed as in mammography. In crystallography, a copper target is most common, with cobalt often being used when fluorescence from iron content in the sample might otherwise present a problem. (Korner2007) [5]

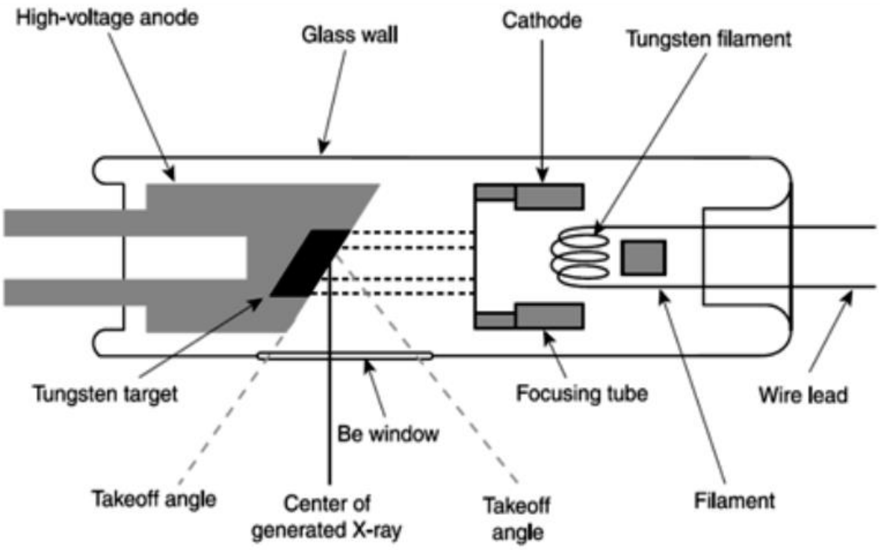

Figure (2.2): X-Ray tube

The maximum energy of the produced X-ray photon is limited by the energy of the incident electron, which is equal to the voltage on the tube, so an 80 kV tube cannot create X-rays with energy greater than 80 KeV. When the electrons hit the target, X-rays are created by two (Korner2007).

2.1.4 Different atomic processes:

X-ray fluorescence: If the electron has enough energy it can knock an orbital electron out of the inner electron shell of a metal atom, and as a result electrons from higher energy levels then fill up the vacancy and X-ray photons are emitted. This process produces an emission spectrum of X-rays at a few discrete frequencies, sometimes referred to as the spectral lines. The spectral lines generated depend on the target (anode) element used and thus are called characteristic lines. Usually these are transitions from upper shells into K shell (called K lines), into L shell (called L lines) (Korner2007). [4]

Bremsstrahlung:

This is radiation given off by the electrons as they are scattered by the strong electric field near the high-Z (proton number) nuclei. These X-rays have a continuous spectrum. The intensity of the X-rays increases linearly with decreasing frequency, from zero at the energy of the incident electrons, the voltage on the X-ray tube. So the resulting output of a tube consists of a continuous bremsstrahlung spectrum falling off to zero at the tube voltage, plus several spikes at the characteristic lines. The voltages used in diagnostic X-ray tubes, and thus the highest energies of the X-rays, range from roughly 20 to 150 kV. [6]

Both of these X-ray production processes are very inefficient, with a production efficiency of only about one percent, and hence, to produce a usable flux of X-rays, most of the electric power consumed by the tube is released as waste heat. The X-ray tube must be designed to dissipate this excess heat. In medical diagnostic applications, the low energy (soft) X-rays are unwanted, since they are totally absorbed by the body, increasing the dose. Hence, a thin metal sheet, often of aluminum, called an X-ray filter, is usually placed over the window of the X-ray tube, filtering out the low energy components in the spectrum. This is called hardening the beam. Radiographs obtained using X-rays can be used to identify a wide spectrum of pathologies. Because the body structures being imaged in medical applications are large compared to the wavelength of the X-rays, the X-rays can be analyzed as particles rather than waves. (This is in contrast to X-ray crystallography, where their wave-like nature is more important because the wavelength comparable to the sizes of the structures was being imaged). (Korner2007).

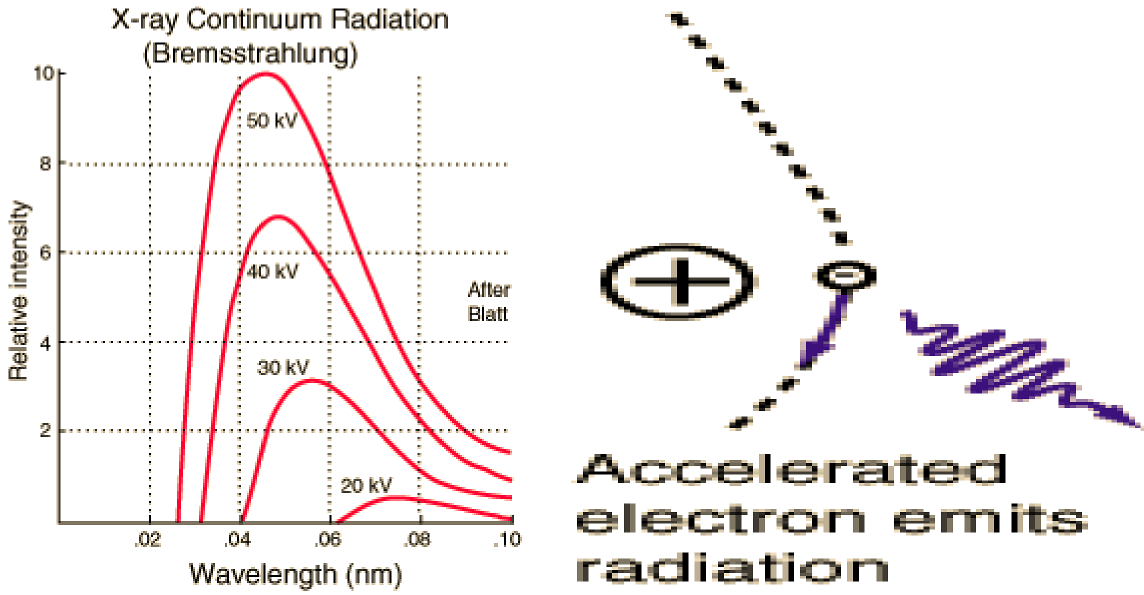

Figure (2.3): Bremsstrahlung X-Rays

2.1.5 Properties of x- rays:

X-rays travel in straight lines; X-rays cannot be deflected by electric field or magnetic field; X-rays have a high penetrating power Photographic film is blackened by X-rays ;Fluorescent materials glow when X-rays are directed at them, Photoelectric emission can be produced by X-rays and Ionization of a gas results when an X-ray beam is passed through it.(Korner2007).

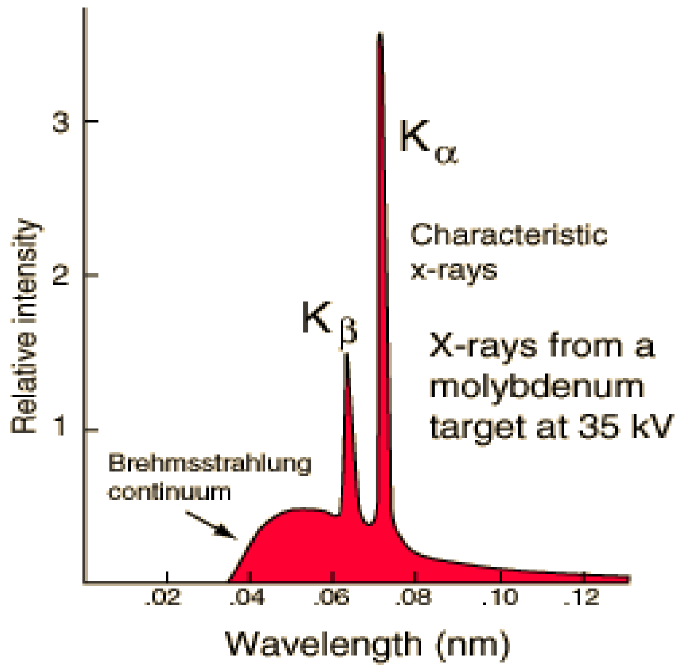

Figure (2.4): shows the Characteristic of x-rays

2.1.6 Radiation dosimetry:

Radiation dosimetry is the calculation of the absorbed dose in matter and tissue resulting from the exposure to indirectly and directly ionizing radiation. It is a scientific subspecialty in the fields of health physics and medical physics that is focused on the calculation of internal and external doses from ionizing radiation. [7]

2.1.7 Radiation quantities:

There are many different physical quantities that can be used to express the amount of radiation delivered to a human body.

Generally, there are advantages and applications as well as disadvantages and limitations for each of the quantities.

There are two types of radiation quantities: those that express the concentration of radiation at some point, or to a specific tissue or organ, and there are also quantities that express the total radiation delivered to a body. We will be considering each of these quantities in much more detail. The general relationship between the concentration and total radiation quantities are illustrated below [8].

2.1.7.1 Exposure:

A radiation quantity that expresses the concentration of radiation delivered to a specific point.

The conventional unit is the roentgen (R) and the SI unit is the coulomb/kg of air (C/kg of air). The unit, roentgen, is officially defined in terms of the amount of ionization produced in a specific quantity of air. The ionization process produces an electrical charge that is expressed in the unit of coulombs [8].

2.1.7.2 Air kerma:

Air kerma is a radiation quantity that is used to express the radiation concentration delivered to a point, such as the entrance surface of a patient's body. It is a quantity that fits into the SI scheme. The quantity, kerma, originated from the acronym, KERMA, for Kinetic Energy Released per unit mass (of air). It is a measure of the amount of radiation energy, in the unit of joules (J), actually deposited in or absorbed in a unit mass (kg) of air. Therefore, the quantity, kerma, is expressed in the units of J/kg which is also the radiation unit, the gray (Gy) [8]

2.1.7.3 Absorbed Dose:

Absorbed Dose is the radiation quantity used to express the concentration of radiation energy actually absorbed in a specific tissue. This is the quantity that is most directly related to biological effects. Dose values can be in the traditional unit of the rad or the SI unit of the gray (Gy). The rad is equivalent to 100 ergs of energy absorbed in a gram of tissue and the gray is one joule of energy absorbed per kilogram of tissue. [8]

2.1.7.4 Entrance Surface dose:

Entrance skin exposure is defined as the exposure in roentgens at the skin surface of the patient without the backscatter contribution from the patient. This measurement is popular because entrance skin exposure is easy to measure, but unfortunately the entrance skin exposure is poorly suited for specifying the radiation received by patients undergoing radiographic examination. The entrance skin exposure does not take into account the radio sensitivity of individual organs or tissues, the area of an x-ray beam, or the beam's penetrating power, therefore, entrance skin exposure is poor indicator of the total energy imparted to the patient [8]

2.1.7.5 Entrance surface air kerma (ESAK):

The entrance surface air kerma (ESAK) is defined as the kerma in air at the point where the central radiation beam axis enters the hypothetical object, i.e. patient or phantom, in the absence of the specified object [9].
(Zoetelief et al, 1996).
The ESD is to be expressed in mGy. That is, whether the definition should refer to the absorbed dose to the air as defined above or absorbed dose to tissue [10].

2.1.7.6 Dose area product (DAP):

Dose area product (DAP) is defined as the absorbed dose to air (or the air kerma) averaged over the area of the X-Ray beam in a plane perpendicular to the beam axis, multiplied by the area of the beam in the same plane. The Gy cm^2 is the preferred unit for DAP [11].

2.1.7.7 Equivalent dose:

In radiological protection, it is the absorbed dose averaged over a tissue or organ (rather than at a point) and weighted for the radiation quality that is of interest (ICRP, 1991). The weighting factor for this purposes is called the radiation weighting factor, W_R, and is selected for the type and energy of the radiation incident on the body, emitted by the source [8]

2.1.7.8 Effective Dose:

The International Commission on Radiological Protection (ICRP), along with other entities concerned with radiation protection, has introduced the concept of dose equivalent in order to discriminate between different types of radiations. The dose equivalent H is defined as the absorbed dose multiplied by a dimensionless factor Q.Q, known as the quality factor, is based on the biological effectiveness of different kinds of radiation, which in turn depends on the linear energy transfer (LET) of that particular radiation. LET is defined by the ICRP as the unrestricted. To account for the differing radio sensitivities of different tissues the ICRP for her introduced the concept of effective dose. A along with the quality factor Q, the absorbed dose is s multiplied by a tissue weighting factor (WT_R) specific to the organ of interest. Since the sum of t the ICRP's tissue weighting factors is unity, each individually weighted organ dose can be summed to obtain an effective dose that represent the risk for all stochastic effects to an irradiated individual. [8]

2.1.8 Radiation Units

2.1.8.1 Roentgen:

The roentgen is a unit used to measure a quantity called exposure. This can only be used to describe an amount of gamma and X-rays, and only in air. One roentgen is equal to depositing in dry air enough energy to cause 2.58 x 10^{-4} coulombs per kg. It is a measure of the ionizations of the molecules in a mass of air. The main advantage of this unit is that it is easy to measure directly, but it is limited because it is only for deposition in air, and only for gamma and x rays. [8]

2.1.8.2 Radiation absorbed dose (Rad):

The rad is a unit used to measure a quantity called absorbed dose. This relates to the amount of energy actually absorbed in some material, and is used for any type of radiation and any material. One rad is defined as the absorption of 100 ergs per gram of material. The unit rad can be used for any type of radiation, but it does not describe the biological effects of the different radiations. [8]

2.1.8.3 (Roentgen equivalent man):

The rem is a unit used to derive a quantity called equivalent dose. This relates the absorbed dose in human tissue to the effective biological damage of the radiation. Not all radiation has the same biological effect, even for the same amount of absorbed dose. [8]

Equivalent dose is often expressed in terms of thousandths of a rem,

Or memo. To determine equivalent dose (rem), you multiply absorbed dose (rad) by a quality factor (Q) that is unique to the type of incident radiation. [8]

2.1.8.4 Gray (Gy):

The gray is a unit used to measure a quantity called absorbed dose. This relates to the amount of energy actually absorbed in some material, and is used for any type of radiation and any material. One gray is equal to one joule of energy deposited in one kg of a material. The unit gray can be used for any type of radiation, but it does not describe the biological effects of the different radiations. Absorbed dose is often expressed in terms of hundredths of a gray, or centi-grays. One gray is equivalent to 100 rads. [8]

2.1.8.5 Sievert (Sv):

The sievert is a unit used to derive a quantity called equivalent dose. This relates the absorbed dose in human tissue to the effective biological damage of the radiation. Not all radiation has the same biological effect, even for the same amount of absorbed dose. Equivalent dose is often expressed in terms of millionths of a sievert, or micro-sievert. To determine equivalent dose (Sv), you multiply absorbed dose (Gy) by a quality factor (Q) that is unique to the type of incident radiation. One sievert is equivalent to 100 rem. [8]

2.1.8.6 Radiation risk:

Repeated exposure to dental X-rays increases thyroid cancer risk, a new study has revealed. Analyzing 313 cancer patients, scientists from Brighton, Cambridge and Kuwait found the chances of developing cancer rose with increasing numbers of dental X-rays. "The public health and clinical implications of these findings are particularly relevant in the light of increases in the incidence of thyroid cancer in many countries over the past 30 years," the Telegraph quoted Dr. Anjum Memon, of the Brighton and Sussex Medical School, as saying. However, Dr. Memon was quick to add that the increasing use of sensitive diagnostic techniques does not necessarily account for the entire increase and that other causes warrant investigation.
(Agencies) [8]

2.1.6.7 Calculation of ESD from Exposure Factors:

ESD may be calculated in practice by means of knowledge of the tube output (Toivonen, 2001). 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 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 back scattered radiation according to the following equation (Toivonen, 2001).

$$ESD = OP \text{ x} \left(\frac{kV}{80}\right)^2 \text{ x mAs x} \left(\frac{100}{FSD}\right)^2 \text{ x BSF} \qquad (2.1$$ [12]

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 therefore 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 whatever Kvp 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. [4]

2.1.9 Thermo luminescence Dosimeters:

TLDs are widely used for patient dosimetry. Tissue equivalent is one of the basic advantages of TLDs in diagnostic radiology. Materials which exhibit thermo luminescence include calcium fluoride, lithium fluoride, lithium borate, calcium borate and several others. The lattice structure of TLDs allow interactions between atoms and alter the electron energy levels creating a band structure specific to the type of lattice system a crystal possesses. The band structure describes energy regions where an electron is able to exist; the lowest energy or ground state is known as the valence band, while the uppermost level is called the conduction band. Non-metallic materials such as TLDs possess an energy region or band gap between the valence and conduction band where electron states cannot exist. Impurities intentionally introduced into TLDs cause irregularities in the band structure, allowing electrons to enter the band gap where they can become trapped. Once the

TLD is irradiated, electrons are excited into the conduction band and eventually fall back to the ground state. Alternately they can fall into a metastable state brought on by the impurity's traps, where they will remain until they receive sufficient energy, driving them back to the valence band. This transition is accompanied by the emission of a photon with energy equivalent to the difference between the excited and ground states.

The light output of the crystal is proportional to the energy initially absorbed from the incident radiation, allowing the exposure to be calculated from the light signal. When the film is processed, the parts of the image corresponding was higher.

2.2 Previous studies:

The most frequency undertaken dental x-ray examination is the intra oral radiograph. The reference dose for intra oral radiography recommended on the basis of the 1999 paper was 4 mGy, for an adult mandibular molar radiography .The 1999 paper also recommended that the reference dose for panoramic radiography should be 65 mGy mm for a standard adult radiograph, and both these values were subsequently as remedial levels in IPEM Report 77 and its recently updated version, IPEM Report 912.Over the course of time, there has been a significant and continual reduction in patient dose for intra oral radiography, and this trend is evident in the data presented in this paper .The result of this study, which covers DXPS's result of x-ray, set assessments over the calendar years 2002 to 2004 demonstrate that the third quartile dose for intra oral radiography has now fallen to 2.4 mGy. For panoramic radiography a much slighter reduction is apparent with the third quartile dose now being 60 mGy mm. This paper examines the underlying causes for the above result and speculates on the scope for further dose reduction in the future.

In study carried by (Mortazavi SMJ 2004; et). In this study, ESD was measured using Life thermo luminescent dosimeters (TLD-100) on the thyroid of 40 patients who had referred to the School of Dentistry, Rafsanjani University of Medical Sciences. Patients were not exposed to any additional radiation and the radiographs were used for diagnostic purposes .TLDs were calibrated with radiation energies similar to those commonly used in orthopan tomography. The panoramic radiographies were performed using the PM 2002 CC unit. The patients' mean age was 29.53 years. Three TLD chips were placed on the thyroid of each patient.

The doses were averaged for each radiographs and mean ESD of all patients calculated .Two different tube voltages were applied (66 and 68kVp). The overall mean ESD (kvps, 6 mA, and 2.5 mm Al filtration) on the thyroid in orthopan tomography was 0.071 ±0.012 mGy (ranged from 0.01 to 0.40 mGy). The mean ESD for radiographies performed with66 Kvp (20 patients) and 68 Kvp (20 patients) were 0.072 ± 0.019, and 0.070 ± 0.016 respectively.

In study carried by (Gulson; et al 2007) entitled Doses to patient arising from dental x-ray examinations in United Kingdom in, 2002-2004, they concluded their study in the following abstract: Previous analysis of the result of routine patient dose measurements have provided data on the range of doses delivered during x-ray examinations in the UK and allowed the derivation of hired quartile values. A previous DXPS study , published in the British Dental Journal in 19901 , recommended adoption of reference doses, based on third quartile doses ,for the two most common type of dental radiograph .

In another a novel study carried by (Osman et al 2010) entitled Radiation Dose Measurements in Routine X ray Examinations; they concluded their study in the following abstract:

The aim of current study was to evaluate patient's radiation dose in routine X-ray examinations in Omdurman teaching hospital Sudan.110 patients was examined (134) radiographs in two X-ray rooms. Entrance surface doses (ESDs) were calculated from patient exposure parameters using DosCalsoftware. The mean ESD for the chest, AP abdomen, AP pelvis, thoracic spine AP, lateral lumber spine anteroposterior lumber spine, lower limb and for the upper limb were;

231±44 μGy, 453±29 μGy, 567±22μGy, 311±33 μGy, 716±39 μGy, 611±55μGy, 311±23 μGy, and 158±57 μGy, respectively. Data shows asymmetry in distribution. The results of the study were compared to previous studies in Sudan.

Chapter Three

Materials and Methods

Chapter 3

3.1 Materials:

This Study intended to assess the thyroid doses for patients during orthopan tomography (OPG) examinations. The data used in this Study was collected from Khartoum Dental hospital, using data sheets, the data has been collected within one month from August 2015 to September 2015

Data collecting sheet**:**

Kvp	mAs	weight	Height	BMI	Age
66	90	73	173	24.4	22
64	90	40.5	145	19.3	25
62	72	50	150	22.2	56
66	72	45	155	18.7	19
66	72	50	185	14.6	35
62	72	76	160	29.7	28
64	72	60	175	19.6	27
64	72	62	170	21.5	19
60	72	51.5	157	20.9	31
66	72	55	158	22	40
66	90	64	161	24.7	29
66	90	65	166	23.6	47
66	90	87	173	29.1	46
64	90	50	170	17.3	18
66	72	75	177	23.9	54
64	72	64	172	21.6	19
66	72	70	181	21.4	27
66	72	50	160	19.5	18

64	72	42	145	20	18
66	90	58	156	23.8	20
66	90	61	170	21.1	19
64	72	62	140	31.6	25
60	90	79	190	21.9	18
60	72	70	153	29.9	40
60	90	50	157	20.3	21
64	90	65	170	22.5	25

3.1.1 Panoramic (OPG) Machine

Figure (3.1): Demonstrate the machine used to carry the examinations

A dental panoramic **Planmeca /Proline XC** machine, radiograph the maxilla and mandible, all the teeth including the "wisdom teeth," the frontal and maxillary

Sinuses, the nasal cavity , the temporomandibular joint and other nearby organs the head and the neck anatomy.

Dental panoramic radiography equipment consists of a horizontal rotating arm which holds an X-Ray source and a moving film mechanism (carrying a film) arranged at opposed extremities.

The patient's skull sits between the X-Ray generator and the film. The X-Ray source is collimated toward the film, to give a beam shaped as a vertical blade having a width of 4-7 mm when arriving on the film, after crossing the patient's skull. Also the height of that beam covers the mandibles and the maxilla regions [1].

The arm moves and its movement may be described as a rotation around an instant center which shifts on a dedicated trajectory. The whole orthopan tomogram process takes about one minute. The patient's actual radiation exposure time varies between 5.5 and 22 seconds for the machine’s excursion around the skull. The manufacturers propose different solutions for moving the arm, trying to maintain constant distance between the teeth to the film and generator. Also those moving solutions try to project the teeth arch as orthogonally as possible.

3.2 Methods:

3.2.1 Population of the study:

A total of fifty patients have been examined; only adult patient’s ≥18 years were involved in the study. All pregnant and infant patients were excluded from the study.

3.2.2 Study area and duration:

The study was done at **Khartoum Dental Hospital,** in the duration from August to September 2015

3.2.3 Variables of the study:

The recorded variables were age, weight, height, body mass index (BMI), which Derived from weight (kg)/ (height (m^2)) and also exposure parameters were recorded.

3.2.4 Radiographic technique:

There was advanced preparation necessary for routine panoramic radiograph. A Hospital used specific protocol for patient’s preparation, the palate of the patient

Fixed on edge of panoramic holder of the machine, canine a crossed with laser cross hair, all patients used to open their mouths during the examination and Adequate immobilization tool were used. Before the examinations were taken, the Radiographer explained the procedure [1].

Figure 3.2 Radiographic image of orthopan tomography (OPG)

3.2.5 Absorbed Dose calculations:

ESD which measured for all patients using mathematical equation in addition to Output factor and patient exposure factors .Measured estimated by a calculation to exposure factors used from formula below.

$$ESD = OP \times \left(\frac{kV}{80}\right)^2 \times mAs \times \left(\frac{100}{FSD}\right)^2 \times BSF \qquad (2.1$$

Where:

(OP) the output in mGy/ (mA s) of the X-Ray tube at 80 kV at a focus distance of

1 m normalized to 10 mAs, (kV) the tube potential, (mAs) the product of the tube (kV) the tube potential, (mAs) the product of the tube current in (mA) and the exposure time in (s), **(FSD)** the focus-to-skin distance (cm).

(BSF) the backscatter factor, the normalization at 80 kV and 10 mAs was used as the potentials across the X-ray tube and the tube current are highly stabilized at this point. BSF was calculated automatically by the Dose Cal software after all input data were entered manually in the software. The tube output, the patient anthropometrical data and the radiographic parameters (Kvp, mAs, FSD and filtration) were initially inserted in the software. The kinds of examination and projection were selected afterwards [12].

3.2.6 Methods of data analysis: Data were analyzed using SPSS, and Microsoft Excel program.

Chapter four

Results

Chapter four

4.1 Results:

The dose calculation concept in diagnostic radiology was consider more important in term of radiation protection and patient safety this study was conducted from August to September 2015, data used in this Study was collected from Khartoum Dental Hospital .

Table (4.1): Shows the descriptive statistics of technical variables used in dose calculation in addition to the dose received

	Minimum	Maximum	Mean	Std. Deviation	Variance
Kv	60	68	64.74	1.988	3.951
mAs	72	90	79.92	9.026	81.463
BMI	14.6000	32.2000	23.342000	3.8307611	14.675
ESD	2.6284	4.0969	3.397375	.4139962	.171

Table (4.2): Shows the descriptive statistics (rang, min, max, mean± Std.Deviation) of patient related variable

Variables	Range	Minimum	Maximum	Mean ± Std. Deviation
Weight	47.5	40.5	88.0	65.52±11.6593
Height	52	140	192	167.92±13.398
BMI	17.6	14.6	32.2	23.342±3.8308
Age	49	18	67	37.02±16.622

Table (4.3): Shows correlation between ESD and Kvp

Correlations

		ESD	Kv
ESD	Pearson Correlation	1	.369**
	Sig. (2-tailed)		.008
	N	50	50
Kv	Pearson Correlation	.369**	1
	Sig. (2-tailed)	.008	
	N	50	50

**. Correlation is significant at the 0.01 level (2-tailed).

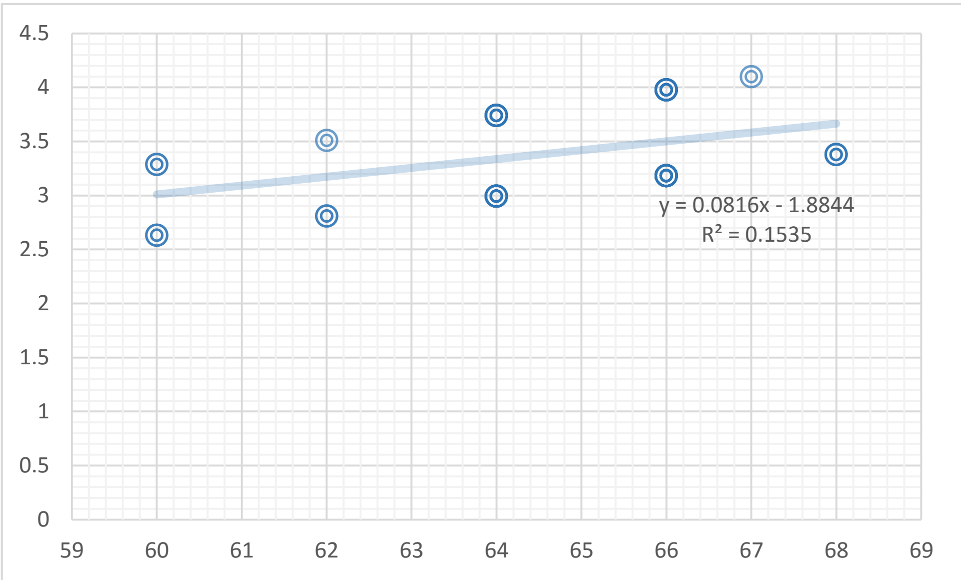

Figure (4.2): scatter plot shows correlation between ESD of thyroid and KVP

Table (4.4): Shows correlation between ESD and BMI

Correlations

		BMI	ESD
BMI	Pearson Correlation	1	-.103
	Sig. (2-tailed)		.475
	N	50	50
ESD	Pearson Correlation	-.103	1
	Sig. (2-tailed)	.475	
	N	50	50

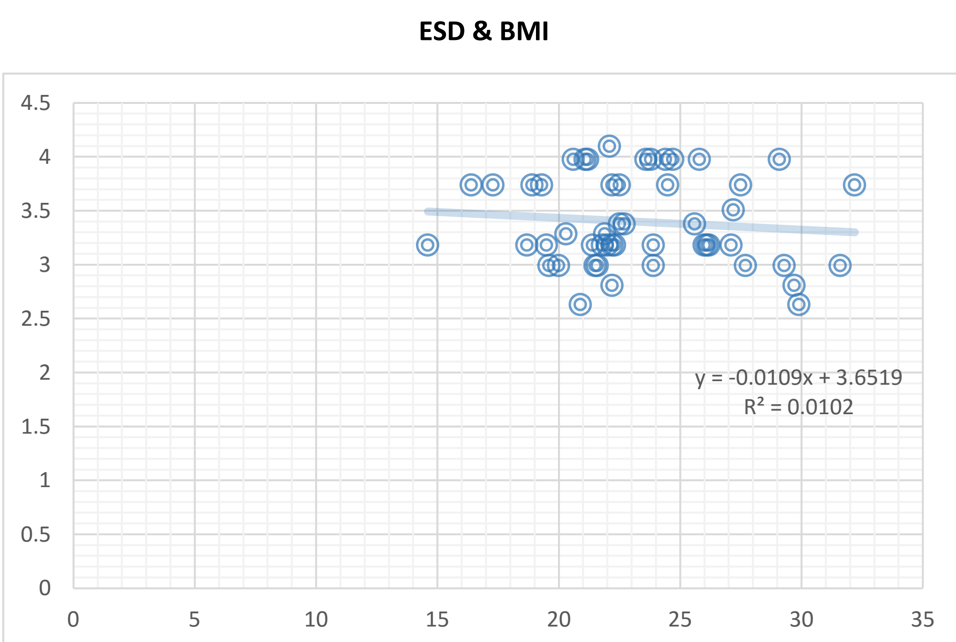

Figure (4.2): scatter plot shows correlation between ESD of the thyroid and BMI used during OPG examination

Table (4.5): Shows correlation between ESD and mAs

Correlations

		ESD	mAs
ESD	Pearson Correlation	1	.882**
	Sig. (2-tailed)		.000
	N	50	50
mAs	Pearson Correlation	.882**	1
	Sig. (2-tailed)	.000	
	N	50	50

**. Correlation is significant at the 0.01 level (2-tailed).

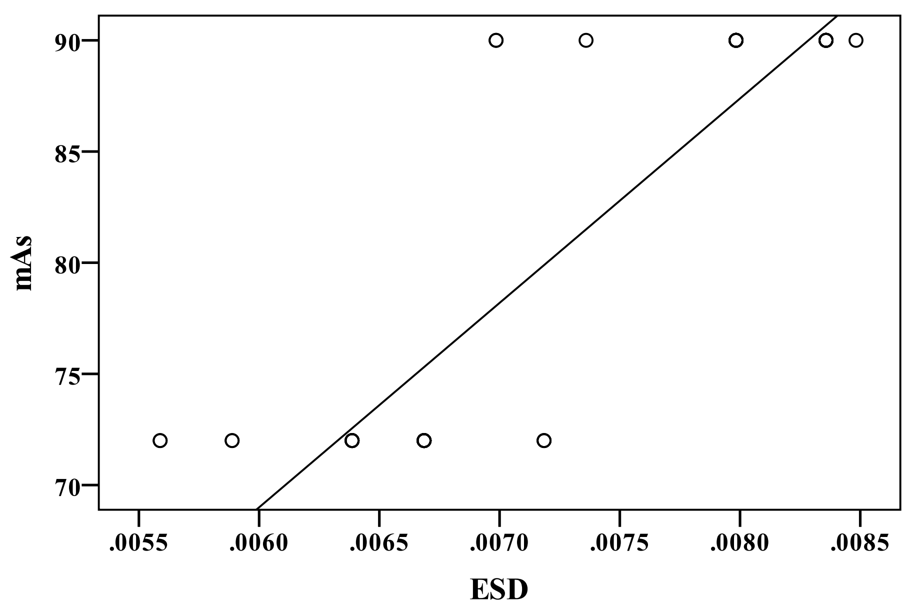

Figure (4.3): scatter plot shows correlation between ESD of thyroid and mAs.

Chapter five

Discussion, Conclusion .Recommendations

And References

Chapter five

5.1 Discussion:

This study aimed to calculate Entrance Skin Dose for thyroid gland during orthopan tomography OPG examination. Samples were collected from Khartoum dental hospital from fifty patients and the data contained all patients related variables such as weight, height, BMI and age, when had mean ± Standard Deviation of 65.52±11.6593, 167.92±13.398, 23.342±3.8308 and 37.02±16.622 respectively, which were showed in Table (4:1). Table (4:2) also technical variables calculation of both ESD of the jaw and thyroid such as Kvp, mAs, ESD for OPG which having mean ± Standard Deviation of 64.74±1.988, 79.92±9.026, 3.397±0.4139 respectively. This value of ESD of OPG was considered acceptable in contrast with international acceptable level 3.45 ± 0.67 mGy as stated by World Science Research Journals 2013 [13].

These doses can be affected by many factors that can increase or decrease the dose accordingly so correlation made with Kvp which affect the entrance skin dose in direct relationship and increase dose by 0.0098 mGy for every one kilo-voltage increase in Kvp. (R^2 value= 0.154) significantly because this voltage used for penetration of the object rather than the amount of radiation used for the examination.

A strong correlation was noted between dose received by thyroid during orthopan tomography OPG examination but scatter appear distributed in constant manner also affect dose directly by 0.0048 mGy increased for every one mAs (R^2=0.758) this strong correlation possibly explained by IAEA, 2004 (14) which stated

That mAs directly increase dose because of increased of amount of radiation and electronic density.

Patient related variable was correlated to show how it could affect these received doses.BMI had inverse relations with thyroid dose which could decrease dose by (0.0013) mGy for every one (Kg/cm^2) (R^2 = 0.0102).

5.2 Conclusion:

The aim of this study to assess the patient exposure received by the thyroid gland during Ortho-Pan-Tomography “OPG” examinations.

The experimental work was performed among random sample of fifty patients collected from Khartoum Dental hospital, the patients experience to orthodontic, trauma and impact of eighth molar.

The data were analyzed by using statistical processing program which showed the value of thyroid dose during orthopan tomography (3.397 ±0. 4139) and the Kvp which affect the entrance skin dose in direct relationship and increase dose by 0.0098 mGy for every one kilo voltage increase in Kvp.

The Dose received by thyroid during OPG increased for every one mAs (R2 =0.758), which had direct relationship; BMI had direct relation with thyroid dose.

One of the study limitations was the unavailability of the TLDs

5.3 Recommendations:

The dentists and trainers must have high knowledge about OPG machine to avoid the significant dose during diagnosis.

The dentists and trainers should know the most radiosensitive organs such as lens, thyroid and salivary glands.

The exposure should be following the international rules of exposure and acceptable exposure factors in order to achieve ALARA principle.

Patients should be well instructed about the procedure to avoid repetition of the radiograph. Also should be protected with lead aprons and the inverse square law should be considered.

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Appendices

5.5.1 Data collecting sheet:

Kvp	mAs	weight	Height	BMI	Age
66	90	73	173	24.4	22
64	90	40.5	145	19.3	25
62	72	50	150	22.2	56
66	72	45	155	18.7	19
66	72	50	185	14.6	35
62	72	76	160	29.7	28
64	72	60	175	19.6	27
64	72	62	170	21.5	19
60	72	51.5	157	20.9	31
66	72	55	158	22	40
66	90	64	161	24.7	29
66	90	65	166	23.6	47
66	90	87	173	29.1	46
64	90	50	170	17.3	18
66	72	75	177	23.9	54
64	72	64	172	21.6	19
66	72	70	181	21.4	27
66	72	50	160	19.5	18
64	72	42	145	20	18
66	90	58	156	23.8	20
66	90	61	170	21.1	19
64	72	62	140	31.6	25
60	90	79	190	21.9	18
60	72	70	153	29.9	40
60	90	50	157	20.3	21
64	90	65	170	22.5	25

Figure 5.1 Radiographic image of orthopan tomography (OPG)