JULY 2017

M.Sc. in Physics Engineering

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EVALUATION OF THE ACCURACY AND EFFICIENCY OF THE *IN VIVO* DOSIMETRY SYSTEMS FOR WHOLE BRAIN CANCER PATIENTS

M.Sc. THESIS

IN

PHYSICS ENGINEERING

BY

ASKLA AZAD JABARY

JULY 2017

Evaluation of the Accuracy and Efficiency of the *in vivo* Dosimetry Systems for Whole Brain Cancer Patients

M.Sc. Thesis

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Physics Engineering

University of Gaziantep

Supervisor

Assoc. Prof. Dr. Vural E. KAFADAR

by

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July 2017

REPUBLIC OF TURKEY
UNIVERSITY OF GAZİANTEP
GRADUATE SCHOOL OF
NATURAL & APPLIED SCIENCES
PHYSICS ENGINEERING

Name of the Thesis: Evaluation of the Accuracy and Efficiency of the *in vivo* Dosimetry Systems for Whole Brain Cancer Patients.

Name of the student: Askla Azad JABARY

Exam date: 31.07. 2017

Approval of the Graduate School of Natural and Applied Sciences.

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Askla Azad JABARY

ABSTRACT

EVALUATION OF THE ACCURACY AND EFFICIENCY OF THE *IN VIVO* DOSIMETRY SYSTEMS FOR WHOLE BRAIN CANCER PATIENTS

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M.Sc. in, Engineering Physics
Supervisor: Assoc. Prof. Dr. Vural Emir KAFADAR
July 2017
58 pages

In external beam radiotherapy quality assurance is carried out on the individual components of the treatment chain. The patient simulating device, planning system and linear accelerators are tested regularly according to set protocols developed by national and international organizations. In-vivo dosimetry measures the dose to the target volume through indirect measures therefore the most likely method for picking up errors which might occur earlier in the chain. In vivo dosimetry, using diodes or thermoluminescent dosimeters (TLDs) is performed in many radiotherapy departments to verify the dose delivered during treatment. In vivo dosimetry is applied to evaluate the delivered dose to critical organs or in complex geometries where the dose is hard to predict from the treatment. The aim of this study was to verily the response of TLDs type (LiF) use in radiotherapy, using Thermoluminescence detectors to establish calibration procedure for TLDs and to evaluate admission dose obtained by the treatment planning system with measured dose.

Key words: *in vivo* dosimetry, LiF, radiotherapy

ÖZET

TÜM BEYİN KANSERİ HASTALARINDA *IN VIVO* DOZIMETRE SİSTEMLERİNİN DOĞRULUK VE ETKİNLİĞİNİN BELİRLENMESİ

JABARY, Askla Azad
Yüksek Lisans Tezi, Fizik Mühendisliği
Tez Yöneticisi: Doç. Dr. Vural Emir KAFADAR
Temmuz 2017
58 sayfa

Radyoterapide kalite güvencesi, tedavi zincirinin tek tek bileşenleri üzerinde gerçekleştirilir. Hastayı taklit eden cihaz, planlama sistemi ve doğrusal hızlandırıcılar, ulusal ve uluslararası kuruluşlar tarafından geliştirilen protokollere göre düzenli olarak test edilir. *In vivo* dozimetresi, dolaylı önlemlerle hedef hacmine olan dozu ölçer, bu nedenle zincirde daha önce meydana gelebilecek hataları toplamaya en uygun yöntemdir. Tedavi sırasında verilen dozu doğrulamak için birçok radyoterapi bölümünde *in vivo* dozimetre, diyotlar veya termolüminesans dozimetreler (TLD'ler) kullanılır. *In vivo* dozimetri, dozun kritik organlara veya tedaviden öngörülmesi güç olan karmaşık geometrileri değerlendirmek için uygulanır. Bu çalışmanın amacı, TLD'lerin kalibrasyon prosedürünü belirlemek için Termoluminesans dedektörleri kullanarak radyoterapide TLD'lerin (LiF) kullanımının titizlikle yanıtlanması ve tedavi planlama sistemi tarafından alınan dozun ölçülen dozu ile değerlendirilmesidir.

Anahtar Kelimeler: *in vivo* dozimetre, LiF, radyoterapi

To my parents and my family

ACKNOWLEDGEMENT

First and foremost, I would like to acknowledge Almighty God who granted me wisdom, health and strength to overcome life's difficulties and actualizing my set targets and academic achievement.

I would like to express my heartfelt thanks and deep gratitude to my supervisor, Assoc. Prof. Dr. Vural Emir KAFADAR, for the continuous support of my M.Sc., study and research, for his ongoing advice, encouragements, the great moral motivation, patience, brotherly treatment and insight throughout the writing of this research work. I would like to thank Gaziantep Oncology hospital for providing me by discovering all data there, I would like to thank to Şule Baz ÇİFTÇİ, who supported me in all steps in my work from hospital.

My gratitude is due to the head and staff of the Engineering Physics Department for their assistant and support during the years of my study and research.

I would like to show my gratitude and my love to my parent for their support and love through the duration of my M.Sc. life. They have given me an endless enthusiasm and encouragement. I am similarly indebted to all my friends. Especially, my husband PESHAWA, that they helped me in completion of my thesis.

Finally, I would like to thank to those who have helped me in one way or another.

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CHAPTER 1

INTRODUCTION

The physical properties of a solid can be determined by influence the defect in a material structure. That would be studied by different methods, such as (electrical, thermal, optical …etc.). The study of defects or impurity states can lead to understanding the nature and characterization of the material with its associated defects. Such a study can result not only also can lead to techniques which control the defects for suitable applications.

In general, application of thermoluminescence involved at three major area as, radiation dosimetry, age determination and geology, with developing technology, simultaneously thermoluminescence application was grown, the most important utilization area of thermoluminescence is the radiation dosimetry, the most important application areas [1];

i. Personnel dosimetry (extremity dosimetry, whole-body dosimetry, tissue dosimetry)
ii. Environment dosimetry (terrestrial dosimetry,Retrospective dosimetry and space dosimetry)
iii. Clinical dosimetry (diagnostic radiology, radiotherapy)
iv. High dose (food sterilization, nuclear reactors, materials testing)
The prescribed dose provides to the board by determination of radiation therapy, even though sparing contiguous tissues.

By this aim, the great majority of cancer axes depend on treatment quality, by the dose delivery and treatment planning system (TPS). There are many opinions in agreement of in vivo dosimetry (IVD).

Currently, the public methods of in vivo dosimetry obtainable are thermoluminescent dosimeters and diodes that was two most essential methods, however, both have a number of limitations.

By using an ion chamber dosimeter TLDs (thermoluminescence dosimeters) are calibrated. TLDs have been established as a superlative over the years and among lot of materials TLD set as a best and suitable materials for dosimeter application, when TL materials irradiated they store energy in their structure, such as both electrons and holes are trapped in trapping centers. When that material is heated, electrons and holes recombine, at recombination centers, and then light is emitted. In this project, the conventional technique for checking the dose delivered to the patient by receiving radiation therapy is in vivo dosimetry system, the occupations of this each of thermoluminescent dosimeters (TLDs) and silicon diodes. TLD dosimetry has been studied over 30 years.

The methodology involved the preparation of thermoluminescent crystals after being received from the manufacturer is thermal profile and irradiations on the (TLD) for calibration, for determination of the equivalent doses, the illustration method of the geometric treatment measurements to conclude the values of Element Correction Coefficient (ECC) and, Reader Calibration Factor (RFC) of crystals, and the monthly report of radiation dosage. In general, for brain tumor patient must irradiate (300 cGy) in 10 once daily doses approximately in 1 month.

CHAPTER 2

THEORY

2.1 Atom

The term “atom” in Greek language originated which “atoms” meaning unbearable division. The smallest indivisible part of matter, its diameter is approximately 10^{-8} cm, as said by some theorists in the field. As the science developed, it is identified that atoms are also compounded by subatomic particles: neutrons and protons in the nucleus of the atom, and electrons move around that nucleus (Figure 1.1).

The nucleus of an atom is formed by protons and neutrons, nucleons is another name of these particles. Protons charge are positive, and Electrons charge are negative. Neutrons are neutral particles, mean have no exact charge. The electron mass is lesser than a proton’s mass by $\mathbf{1\backslash 1.84}$, the mass of a neutron is very a little larger than proton. The diameter of the atomic nucleus is 10^{-13} cm [2].

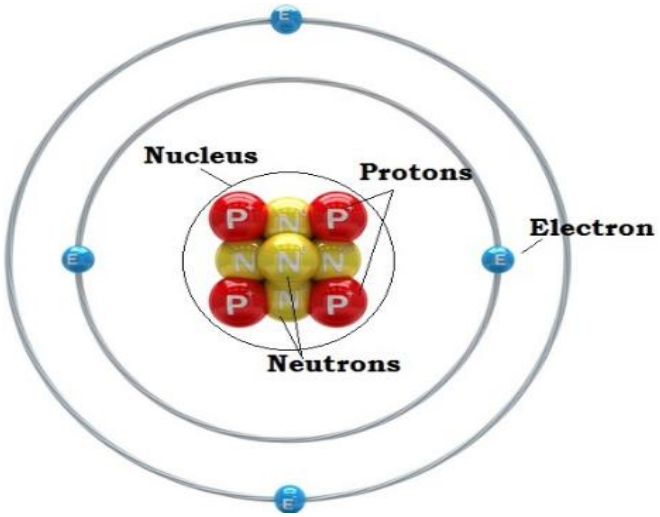

Figure 2.1 The structure of an atom. [3]

2.2 Radiation

The energy distribution from any a radiative source to a medium is called radiation. This transmission of energy can be in different form, electromagnetic radiation or particulate radiation. The collection of different forms of radiation such as visible light, X-rays as well as gamma-rays, all forms are categorized under the terms electromagnetic spectrum. X-rays and gamma-rays, have the highest frequencies and energies, are placed at the end of the electromagnetic spectrum chart. Whereas Radio waves, have the lowest frequencies and energies, and the longest wavelengths of the different types of electromagnetic radiation, are located at end of this chart [4, 5].

2.3 Ionizing Radiation

The ability of remove electrons from atoms is Ionizing radiation. It can be particulate radiation or electromagnetic. Procedures of clinical radiation oncology are particle as electrons or protons or neutrons, and photons as a radiation in the treatment of malignancies and some benign tumor types [6].

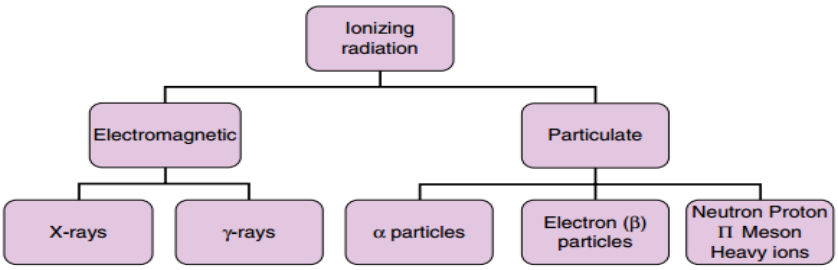

Figure 2.2 Graph of ionization radiation

2.4 Ionizing Electromagnetic Radiation

The electromagnetic spectrum contains electromagnetic radiation. And this includes, radio waves long wavelength, low (frequency and energy), and ionized to short wavelength, high (frequency and energy).

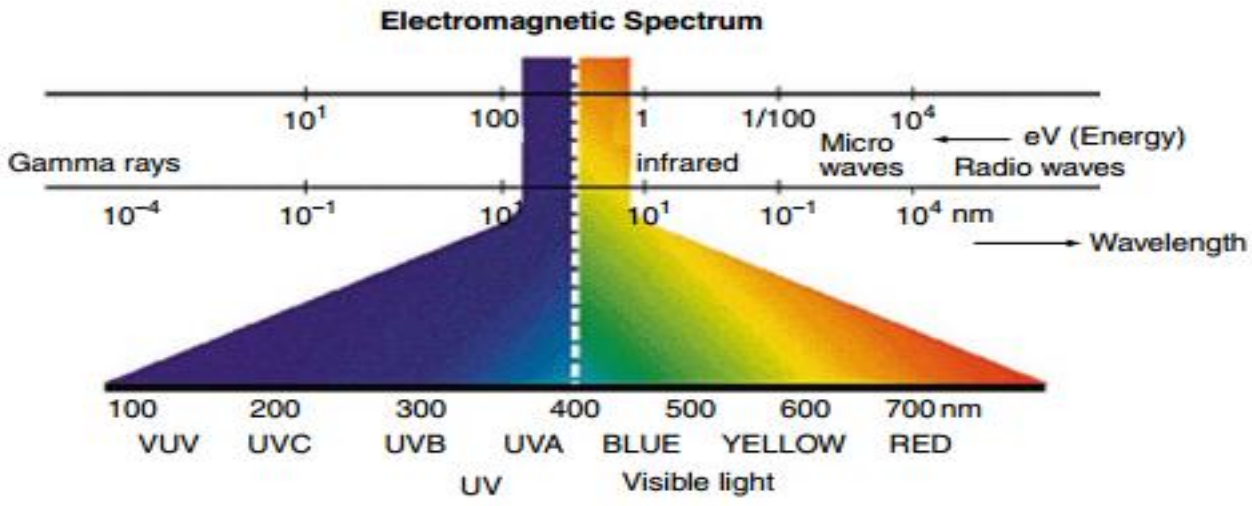

Figure 2.3 The sketch for electromagnetic spectrum.

In The ionization process, the electrons removed from their atomic and molecular orbits while high-energy radiation interrelates with matter. The secondary electrons create during their way to passaging through the material or during the ionization process, a mean of energy-measured as 33.85 eV is transferred [7].

2.5 X- Rays

In 1913, at William David Coolidge, cathode Roentgen tube originate by the German physicist Wilhelm Conrad Roentgen. Which includes glass tube contain cathode and anode, layers between them which at high potential (106 –108 V) is applied the pressured became ($\mathbf{10^{-3}}$ mmHg), (Fig. 2.4).

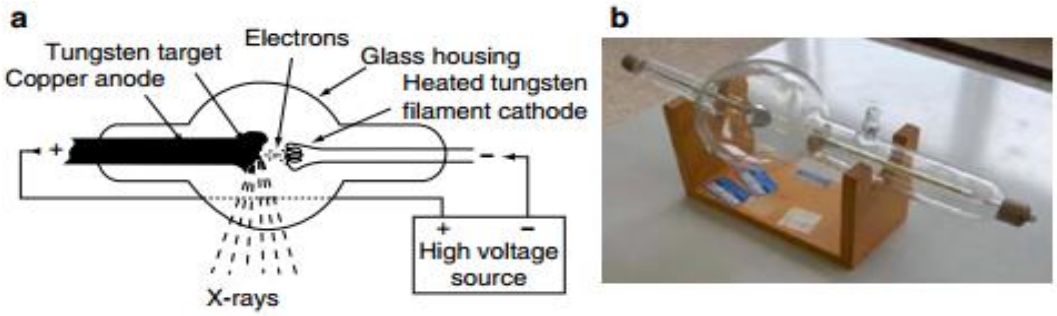

Figure 2.4 (a) Diagram depiction of an X-ray tube, (b) An X-ray tube photograph [8]

Electrons created by thermionic emission in the cathode, elections are accelerated towards the anode by the potential energy form the anode. The coulomb interactions between nuclei in the anode and acceleration of electrons produce X-ray. This rapid deceleration of fast moving electrons is known as bremsstrahlung (Fig. 1.5). The atomic number of the anode metal is characterized which all of the velocity of the electrons, kinetic energy, wavelength and total energy of the X-rays depends on. This process produces medical radiation in analytic X-ray units, in linear accelerators (LINAC) [8].

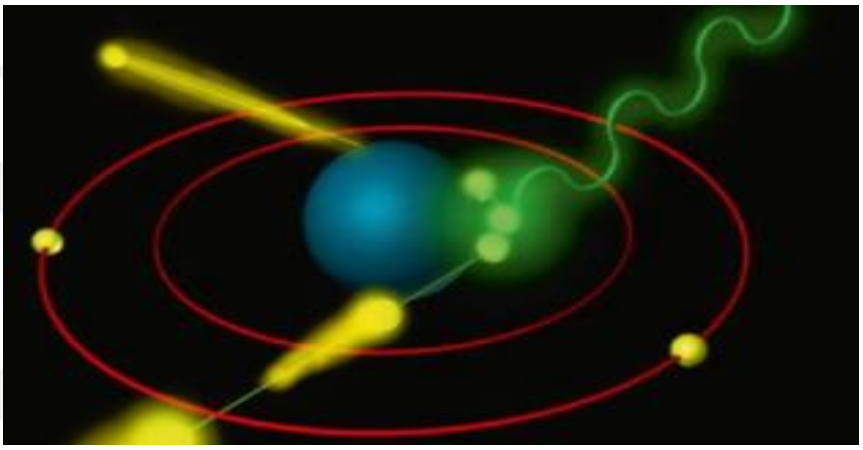

Figure 2.5 Bremsstrahlung process [9]

By extra atomic processes, two kinds of X-rays are produced. first type relates to the bremsstrahlung and second type follows, an electron in an inner atomic orbital is removed out by an incoming electron is filed by another electron orbital that moves from an outer atomic orbital (Fig. 2.6). This electron must get energy to move in this manner orbit, and the energy released is radiated as characteristic of X-rays [7- 9].

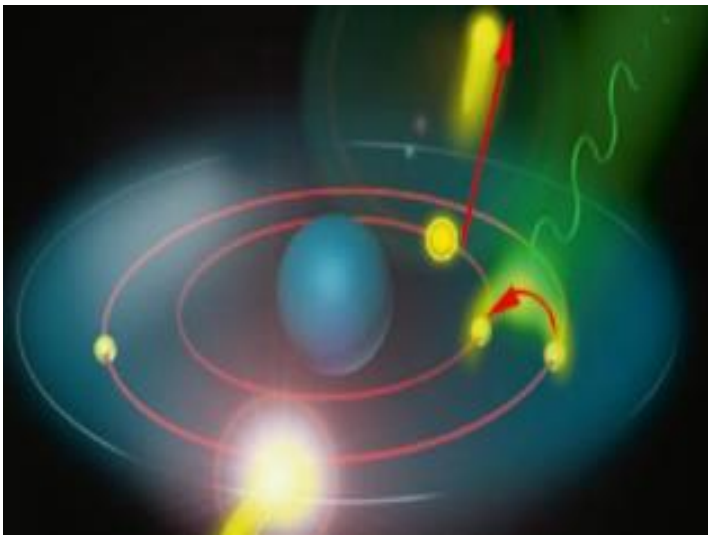

Figure 2.6 Characteristic of X-ray generation [9]

2.6 General Radiobiology

Ionizing radiation at doses used in medicine kills cells by inflicting DNA strand damage. This may be a direct effect of the ionizing radiation on DNA itself or an indirect action brought about by free radical formation. Classic radiobiology taught us that cells die a mitotic death; in other words, die during a subsequent abortive cell division. More recent studies show that radiation may also switch on program med cell death apoptosis. Tumors vary widely in their cell kinetics ranging from very rapidly growing tumors with a high growth fraction and short doubling time [10].

2.7 Radiotherapy

In order to obtain successful ionizing radiations in therapy, it requires giving high doses within a well-defined volume. This will result in killing all the malignant cells that surrounding tissues. It is comparative to know the exact amount of dose received by radiosensitive organs as and tumors into the patient. However, it is often impossible to measure the dose at an organ or tumor explicitly these complications happen in the radiation treatment into the patient. In this case the dose can be calculated in the correct models of patient anatomy as well as the radiation field parameters of the patient s tissue. The accuracy of the dose imparted is very important because inadequate tumor

regressions have been monitored when the dose is 5% blow the given dose. On the other hand, if the dose goes beyond the prescribed value, an improper injury to the normal tissues can occur. The use of modern treatment methods in radiotherapy are computerized then, the depth dose data for different geometries of the radiation field and for given equipment as well as the anatomic data of the patient are kept in the computer memory. This does not mean these advanced, treat plans are perfect and likelihood of error is unexcited. It is imperative to verify these theoretical treatment plans by making explicit dimensions of the dose. Opportunely, the fractionated countryside of the most of the radio therapeutic exposures, which administrate the doses daily along some weeks, the dose administrated during the treatment and consequently its rectification, if it is necessary. The small size of the DTLs is an improvement is big effect to use it in radiotherapy, than uses in radio diagnosis treatment [11, 12].

2.8 Brain

The brain is the mid part of human body that record all sensations. Connecting them together with deposited information, making conclusions, and taking actions. Brain is also center for the attention and concentration, emotional behavior, and memory. The different regions of the brain generalize different roles, and many parts of the brainwork together to complete a particular function. Thus, a tumor or scratch in a particular area of the brain will produce specific symptoms according to the function of the affected section.

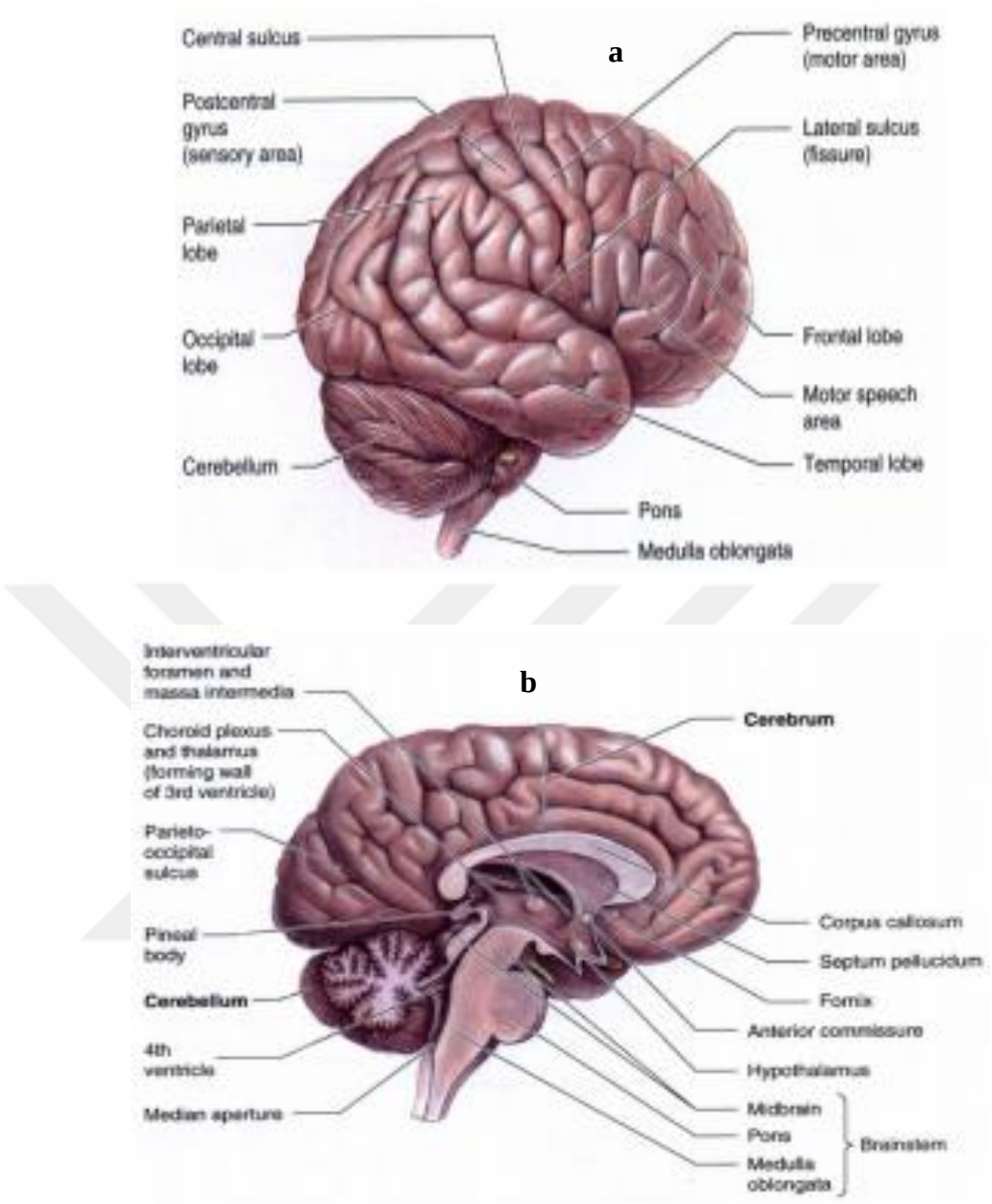

Figure 2.7 (a) Right cross view of right cerebral, (b) Medial view of left cerebral hemisphere. [13]

The hemisphere is encephalon or brain s divisible, for expediency into regions on the centers of morphology and functions. Ascending from the spinal cord these are hindbrain, which includes the medulla oblongata, the pons and the cerebellum, the mesencephalon or midbrain, and the pros encephalon or forebrain, which is represent divided into the diencephalon between brain and the telencephalon. Medulla oblongata, pons and midbrain connecting the spinal cord and for the brain.

2.9 Protective Coverings of the Brain

Cranial bones and the cranial meninges provide the protection for brain. The cranial meninges with its counterpart spinal meninges and they comprise of three thin membranes (Fig 2.8) from the outermost layer inner they are the Dura mater, the arachnoid and the pie mater.

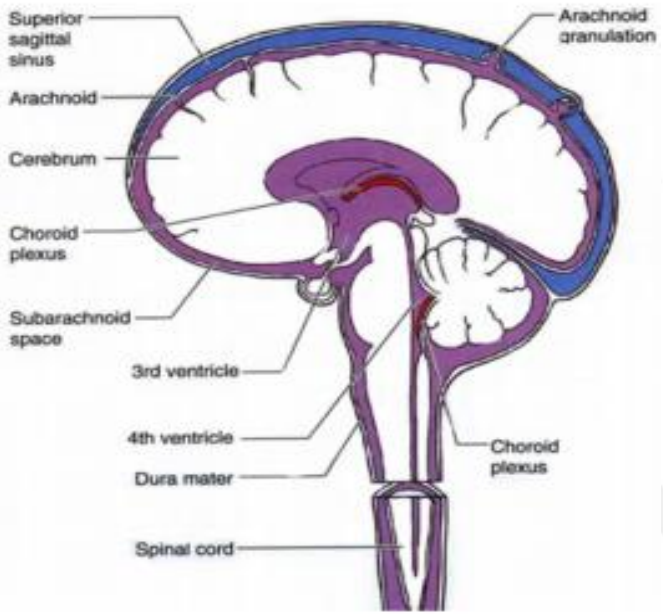

Figure 2.8 Illustration of CSF of the brain and meninges. [13]

Two sides of film or membrane form the Dura mater, the outer layer. Dura in the brain consist of two special parts, the flax and the tentorium. The tentorium splits to higher and lower parts of the brain, and the flax splits to right and left half of the brain.

The arachnoid is composed of slight, flexible tissue and blood pots in different sizes are covers the whole brain. The subdural space is planetary between the Dura and the arachnoid.

The pie mater lies neighboring to the outward of the brain. It has many blood vessels realizing into the surface of the brain and surveys the folds of the brain. The subarachnoid space filled with cerebrospinal fluid it divides the arachnoid pie mater. The Cerebrospinal Fluid (CSF) neutral liquid that have not real colure, and its function is to provide protection the brain and spinal cord, beside chemical change and physical damages. The formation of CSF is created by choroid plexus which is a specialized structure. (Fig 2.8) In each of the four holes in the brain, called ventricles. The ventricular system covers of two midlines and two lateral ventricles. The lateral first and the second ventricles, the, are the largest cavities of the ventricular system which also fill large parts of cerebral hemispheres. The 3rd ventricle, a split like cavity between each halves right and left of the diencephalon, is constant poster inferiorly with the cerebral aqueduct, connecting of the 3rd and the 4th ventricles will be by a narrow channel in the midbrain. The survival of a Blood-Brain Barrier (BBB) and of a blood-cerebrospinal barrier prevents certain (toxic) substances from leaving the blood and entering the brain tissue. However, the brain's subsistence and health depend on these barriers, and they are necessary to check chemotherapy and antibiotics from success tumors and diseases in the brain [13].

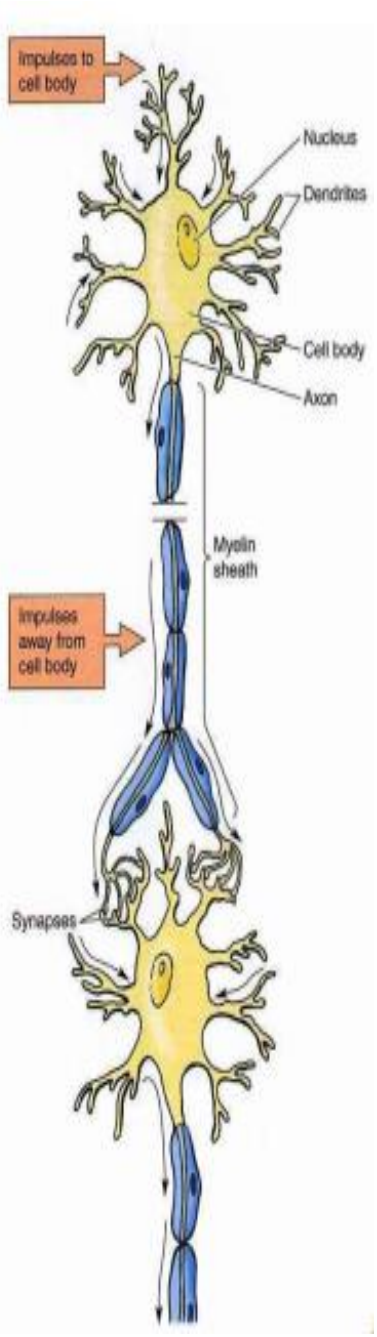

Figure 2.9 Structure of a motor neuron [13]

2.10 Brain cells

The brain is formed by two foremost type as of cell, neurons (nerve cells) and cells that sustenance neurons called as neuroglia (glia cells). The neuron (Fig 2.8) is the structural and efficient. They are unit of nervous system which specified form prompt

communication, And the communication of Neurons with each other at synapses, is the point of contact between neurons. That will transpire by means of neurotransmitters, they are different than other cells in the body, and neurons cannot redevelop formerly.

However, it is examined that the brain has ability and adjust itself in way that it can cure loss and damages occur in brain cells. This can be done by production new interconnections, this happen in Children under the age of six, whose brains are still evolving, and therefore it can be supposed that the adjustment of the brain will improve from neuron damage [14].

They are the types of cells whose compound in tumors, which have created in the brain, and oligodendroglia cells are the types of glial cells generally originate in the brain to. A collection of nerve cell bodies in the CNS is a nucleus [15].

2.11 The Cerebrum

The cerebrum the front part of the brain, is involve two most important parts, right and left cerebral hemispheres, which are connected by the amount of callosum (Fig 2.9). that is connects the right and left side of the brain, and transporting the communications from right to the left of brain or from right to left [15].

The cerebral cortex, which is the thin layer (2 - 4 mm) of gray matter on the outward of the cerebral hemisphere, has larger channels (fissures), small channels (sulci) and bulges between the channels called gyri. They attend as landmarks and they are useful for separate the important area of the brain. The brain effectively separated into pairs of lobes Because of founding landmarks in the outward of a brain. Those lobes have a wide area of the brain, each hemisphere has a frontal, occipital, parietal, and temp oral lobe as shown in (Fig 2.8).

The integrates motor, and cerebrum controls, sensory and mental functions like thoughts, emotions and memory, as well as personality. It is also responsible for thinking, learning, reasoning, and memory, the functions mostly associated with intelligence.

Frontal lobes. The frontal lobes of the cerebrum have a lot of work in brain, like help us thinking in logical way and to behave in socially acceptable way. It also assists humans with arrangements prioritization, contraption and anger management or behavioral controlled. Injuries or Damage occur to the followed part of the lobes can result in changing social behavior such as unpleasant and offensive ones. A strip of brain with different sections, the back of the frontal lobe is called as motor space, controlling motor stroke such as talking, munching, permitting, motion of the hand, legs, and toes [14].

The premotor cortex is a section founded near the primary motor cortex. It controllers our motion of eye and head, and control the sense of position.

Broca's area, is originate in the frontal lobe, frequently on the left side of brain, useful to product the language.

Parietal lobes are front of the parietal lobes, known as the sensory zone, whose disturbed the sensations pending in from which part of body the eyes, ears, tongue, nose or other body part. At the other hand, the parietal lobes have another important work, which conjoining the data from the memory and new information that is established provides meaning to objects. Construe sensory signs that traded from other parts of the brain like hearing, vision, sensory, motor and memory to. Occipital lobes, the occipital lobes are the graphic center of the brain, constructing those information that coming into the brain from the sight senses. This section is called the visual cortex. The occipital lobe on the right construes visual signals from the left visual area, while the left occipital lobe has a same for the right visual area. Damage to one occipital lobe might causes to loss vision in the opposite visual side.

Temporal lobes - The temporal lobes, the lower lateral lobes of the cerebral hemispheres, are complicated with talking, hearing, language, and memory.

2.12 Cerebellum

The second largest part of the brain is cerebellum (small brain), that located near the posterior portion of the cerebrum, a transverse fold of Dura mater, and the occipital lobes named tentorium, the size of a goose egg and weighs about 130-140 g is separates

the cerebellum from the cerebrum. Its surface is characterized by many small fissures, less prominent than those of the cerebrum (Fig 2.7 A and B). Controlling of skeletal muscles will related to the cerebellum, and they include keeping posture equilibrium, the fine tuning of motor activity, and muscle tone or movement, including control over fast (repetitive)movements. A tumor or scratch in the cerebellum may cause ataxia. This is a malfunction of matched movements, which leads to hysterical, staggering, and irregular movements [15].

2.13 The Diencephalon

The part of the brain found between the cerebrum and the midbrain is called as diencephalon. And it contains of several structures placed around the third ventricle, the main ones are the thalamus (dorsal thalamus and epithalamiums) and the hypo thalamus.

The thalamus is nearly have a length in 3 cm, and formed as elliptical shape in the midbrain. That comprises of two elliptical masses of generally gray matter primed into nuclei in the sideways of third ventricle and the masses are combined by a bridge of gray matter called the Massa inter media (Fig 2.7). The thalamus is serves spread position of all data that reserved to cerebral cortex. It plays a character in pain sensation, attention, and alertness [15].

The hypothalamus is placed the 3rd ventricle's floor and the lower part of its sidewall and consists of several structures that lie below the thalamus. The hypothalamus is related to all data that comes from the external situation and have a role in controlling our performance such as sleeping, eating, sexual, and temperature normalization of our body. It has some important connections with the pituitary gland. Which the pituitary gland produces in an addition of the hypothalamus downstairs, and from other component spreading upward from the rooftop of the mouth. The pituitary gland is complicated in controlling a number of hormonal functions such as thyroid functions, growth and sexual maturation.

2.14 The Brain Stem

The brain stem is controls the most basic functions, which composed of the medulla oblongata, the pons and the midbrain (Fig 2.7). The cranial nerves controller important functions such as facial movement, swallowing, the senses, shoulder and neck muscles, originate in the brain stem. The brain stem attends as a relay position, transition communications through various parts of the body and cerebral cortex. Controlling functions of several humble original that are important for the existence that located in brain stem. The controlling of left side of the brain will don by the right side of the body and vice versa. Thus, any founding tumors on one side of the brain is effect of motion and sensation on the opposite side of the body.

The pons lies directly above the medulla and anterior to the cerebellum, and it measures about 2.5 cm in length. As the name implies, the pons is a bridge connecting the spinal cord all parts of the brain.

Fibers are provided these connections in two principal orders. The longitudinal fibers of the pons be owned by the motor and sensory parts that connect the spinal cord or medulla with the higher parts of the brain stem. The transverse fibers connect with the cerebellum through the middle cerebellar peduncles [15].

The mesencephalon, or midbrain, ranges from the pons to the lower portion of the diencephalon, and is about 2.5 cm in length. The cerebral aqueduct passes through the midbrain and connects the third ventricle above with the forth ventricle below. The ventral portion of the midbrain encloses a couple of fiber bundles mentioned to cerebral peduncles. The cerebral peduncles contain many motor fibers that convey impulses from the cerebral cortex to the pons and spinal cord. They contain sensory fibers that permit from the spinal cord to the thalamus. The cerebral peduncles create the connection of tracts between upper and lower parts of the brain. The tectum is dorsal portion of the midbrain contains four rounded distinctions. The two superior colliculi gives reaction centers for movements of the eyeballs and head in response to visual and other stimuli [15].

2.15 Cranial Nerves

Cranial nerves (CN), are one of the peripheral nervous system. All of cranial nerves are 12 pairs, which developed from the brain stem, the cranial nerves are labelled by roman digits and names. The roman numerals direct to the order, from forward to posterior, in which the nerves ascend from the brain. Cranial nerves develop from the nose, the eyes, the brain stem, and the spinal cord. Two cranial nerves (nose, eyes) are sensory nerves because it contains only sensory fibers. The remainder are assorted nerves that surrounded both of motor and sensory neurons [14].

2.16 Brain Tumors

The human body is invented of many different structures of cells. Which if perceive any kind of these cells, understand that every cell has singular functions. Maximum cells in the in different body organ grow, and procedure new cells by divided in a logical way to keep the body strong. Lose the ability to control growing of cell without any order, and made of these extra cells, form a mass in tissue called as tumor. In which the generally type of tumor in brain is usually benign or malignant.

Benign brain tumors do not contain cancer cells. In which they are grow slowly, they are covering with fibrous, some time they occupy the brain, and they can also remove by treatment operation. Because of their location, and their grade. A benign brain tumor may same time not able to remove. Then a benign tumor can be a thoughtful problem because while they do not nearby to tissue, make a big pressure to sensitive organ of the brain and cusses indications.

Malignant brain tumors are cover cancer cells. They are life threatening and interfere with vital functions. Tumors are possible to rapidly growth, usually absence a covering (no encapsulation) and they crowd or invade the tissue around them. Brain tumor mentions to some grade, from low grade (grade I), to high grade (grade IV). When tumor cells looked under a microscope the grade of a tumor states. The Cells which are in higher grade tumors are growth faster compare with cells that was in lower grade tumors [16].

2.17 Primary Brain Tumors

Primary brain tumors are that tumors create in brain tissue and they are classified by the tissues type. The tram (oma) simply means mass that relate for many tumors. The public brain tumors are gliomas which originate in the glial (sympathetic) tissue. In which there are different types of gilomas. Astrocytomas is one of them, possibly they grow in differ reign in the brain or same time in spinal cord. They star in small cells known as astrocytes. They arise in the brain stem or in the cerebrum, and the cerebellum in childrens age. As so as in the cerebrum in adults age. There are two grades of astrocytoma, (IV and III) which called as glioblastoma multiforme and anaplastic astrocytoma repeatedly [17].

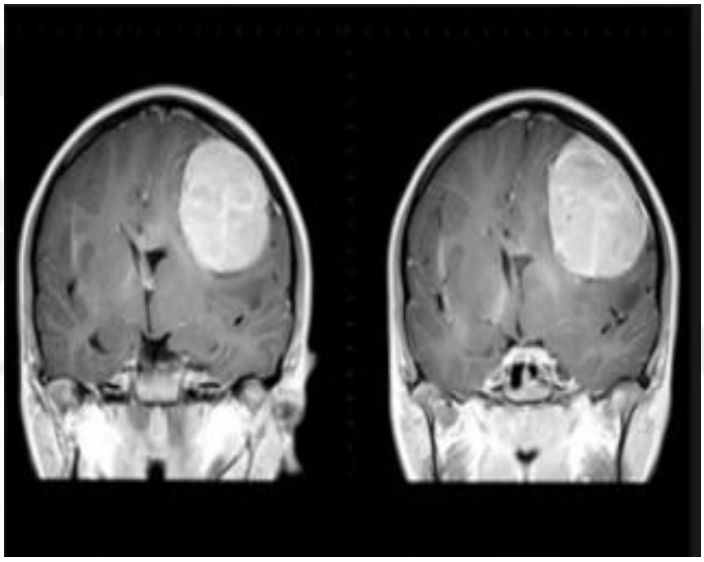

Figure 2.10 Malignant brain tumors [51]

Brain stem glioma like part of the brain follow in the lowest. Usually if Tumor found in this region cannot be removed when take treatment, because all of brain stem gliomas are in high-grade astrocytomas.

- Ependymomas this kind of tumor generally grow in the cover of the ventricles. Or in some cases in the vertebral cord. Although these tumors can be found at any age, exactly in childhood and teens.
- Oligodendroglioma this type gets up in the myelin cells, who's full of fat and covering the protect nerves. They usually arise in the cerebrum, and grow slowly, they do not

spread into neighboring brain tissue. Oligodendrogliomas are a type of tumors that no common a lot through different age, but some time arise in medium-aged adults. Some of the most types of brain tumors that do not begin in glial tissue are described below:

- Medulloblastoma called primitive neuroectodermal tumors (PNET) too because the primitive nerve cells that not keep on in the body after birth will develop medulloblastomas, all medulloblastomas ascend in the cerebellum. Generally, these tumors transpire in children, and public in boys than in girls.
- Meningioma these tumors grow so slowly then they transfer to benign tumors, and may be some time brine have adjusted ion to their presence. Generally, these tumors occur most females a lot exactly in 30 to 50 ages.
- Schwannoma they start growing in schwann cells, the cells that protects the acoustic nerve, whose produce myelin, generally this tumor accrue in adult and spatially in woman [17].
- Craniopharyngioma grow in the pituitary gland area near the hypothalamus. They are usually benign however, they damage the hypothalamus and make pain on dynamic functions, by producing a pressure on brain cells, typically they considered malignant tuamor too, and these tumors may be found in children and teenagers.
- Germ cell tumors that ascend in germ cells or in original sex cells.

Pineal region tumors a small organ that was nearby to the midd of the brain occur in or around the pineal gland, they called (pineocytoma) tumor in case they can be slow growing, or (pineoblastoma) event they fast growing. These tumors regularly cannot be removed because the pineal region is very problematic to spread [17-20].

2.18 Secondary Brain Tumors

The Cancer originates in other organ of the body and spread to the brain by the bloodstream and cause secondary tumors, because of that the called as spread of cancer. They are different than primary brain tumors. Because in primary brain tumor the tumor organ at brain not in other part of body. Cancer that spreads to the brain have differ name it was same name of that organ that begin. In which if it was in lung called metastatic lung cancer, because hear produce abnormal lung cells, not abnormal brain

cells. Primary brain tumors rarely spread to other areas of the body, but they can spread to other parts of the brain and to the spinal axis [17, 18].

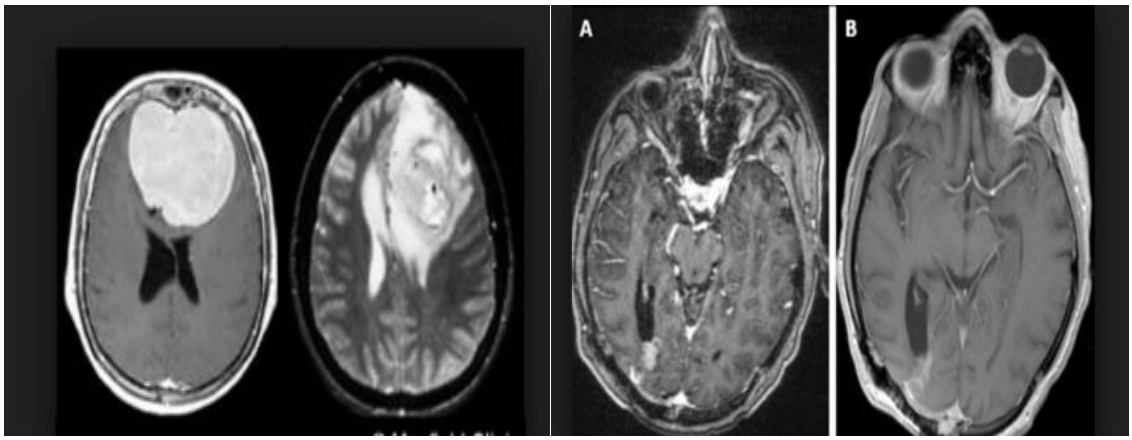

Figure 2.11 Metastasis Brain Tumors [19]

2.19 Possible causes of Brain Tumors

The causes of brain tumors are not known. Brain tumors are not spreadable, that mean it is not contagious. Scientist show that the brain tumors can arise at any age, in children same time or in adult age to. By reviewing large numbers of patients of brain tumor, prison that work in danger factors for example oil filtering, rubber engineering, and medicine built-up may catch brain tumor. Although researchers also are looking at experience to viruses as a possible cause, because brain tumors sometimes occur in several members of the same family, heredity is investigated as a possible cause.

2.20 Luminescent

When radiation is incident on an insulator or semiconductor some of its energy are absorbed and re-emitted as light of a longer wavelength “Stoke's law” this process is called luminescence,and these materials and substances that are capable of emitting light, particularly in the visible range are termed “luminescent”. In nature, most of the materials possess luminescent properties [21].

The wavelength of the emitted light is characteristic of the luminescence substance and not of the incident radiation. Usually, most studies of luminescence phenomena

are concerned with the emission of visible light but other wavelength can be emitted, such as (ultra-violet or infra-red). Sometimes luminescence emission resulting from heat, or by chemical reactions, electrical energy, subatomic motions, and stress on a crystal. The various luminescence phenomena are named according to method of excitation energy. Such as photoluminescence, radioluminescence, cathodoluminescence, etc…[22].

The emission phenomenon of the light takes place after characteristic time (τ_c) which this parameter (τ_c) allows us to subdivide the process of luminescence into two parts phosphorescence and fluorescence. The (τ_c) of fluorescence is smaller than (10^{-8}s) but phosphorescence is greater than (10^{-8}s) by this difference we can distinguish between the phosphorescence and fluorescence. Fluorescence emission is basically a spontaneous process because its (τ_c) value is smaller than (10^{-8}s), which after simultaneously absorbing the radiation immediately ceases when the radiation ceases.

Phosphorescence emission is the time interval which is starting the radiation absorption till reach to maximum intensity (t_{max}) and the (τ_c) value of the phosphorescence is greater than (10^{-8}s) and has been seen to continue for some time after removing the excitation. However, it is more complex to distinguish between phosphorescence and fluorescence when the time of delay is too short. And the phosphorescence itself can be subdivided into two main kinds [23].

One is the short period phosphorescence ($\tau c < 10^{-4}$ s) and another one is the long period phosphorescence ($\tau c > 10^{-4}$s). Another different between the fluorescence and the phosphorescence is the effect of temperature on the decay of luminescence clearly through practical viewpoint. Phosphorescence is heavily dependent on temperature, whereas the fluorescence is not dependent on temperature [21].

2.21 Thermoluminescence

The substances like insulators or semiconductors artificially or accidentally are exposed to radiation, and the radiation causes absorb energy at a given temperature, and emit this energy in the form of visible light while heating the sample. This thermally stimulated phenomenon can be called as luminescence or

thermoluminescence. However, the mechanism of thermoluminescence (TL) is not simple as this explanation [24, 25].

Thermoluminescence has been used extensively to measure nuclear radiation doses since the early 1950s following the commercial availability of sufficiently sensitive and reliable photomultiplier tubes. Thermoluminescence was subsequently applied to archaeological dating in the early 1960s and to geological dating in the beginning of the 1980s, Techniques and methods used in thermoluminescence dating are reviewed by Aitken [26, 27].

Thermoluminescence is a process differs from the light emitted spontaneously from a substance when it is heated to incandescence. Say over 200 ^{o}C (or at high temperatures) a solid substance emits (infra-red) radiation of which the intensity of it increases with increasing temperature, this process is called (thermal) or (black body radiation). To emit the light in stimulate, it needs to add some energy levels among the forbidden energy band gap, these energy levels create caused of lattice defects by insert some impurities into host lattice in thermoluminescence materials which these states are called “metastable state”. The lattice defects are the most important parameters to understand the thermoluminescence phenomenon. They occur naturally or artificially and induce electronic states in the forbidden band [28, 29].

2.22 Thermoluminescence (TL) Mechanism

Thermoluminescence (TL) method is a relatively complex process since it includes a trap and a luminescence center. The fundamental thermoluminescence phenomenon is given in the (Fig 2.12). As can be seen, there are two bands within the system. One of them is the conduction band which is an energy band in a solid. Electrons are freely mobile in this band and they can produce a net electric current. The other is valence band which is the outermost energy band that contains electrons when a solid is in the ground state [30]. Due to radiation which is applied to thermoluminesent material, raises electrons from the valence band and trapped in some energy level in the forbidden gap near to the conduction band (electron trap) is happened. Simultaneously, resulting holes may be trapped at other energy levels that are also within the forbidden gap which Electrons are freely mobile in this band and they can produce a net electric current. The other is valence band which is the outermost energy band that contains

electrons when a solid is in the ground state which are named as the hole trap or recombination center [30, 31]. And the light must be emitted when these trapped electrons out of the trap and come down to the lower energy level by heating the sample [32].

In sum, thermoluminescence can be described by two stages. First stage is the change of the system from equilibrium to excited state by absorption of energy from any radiation source. Then the second stage is relaxation of the system back to the equilibrium by energy release such as light with the help of thermal stimulation [25].

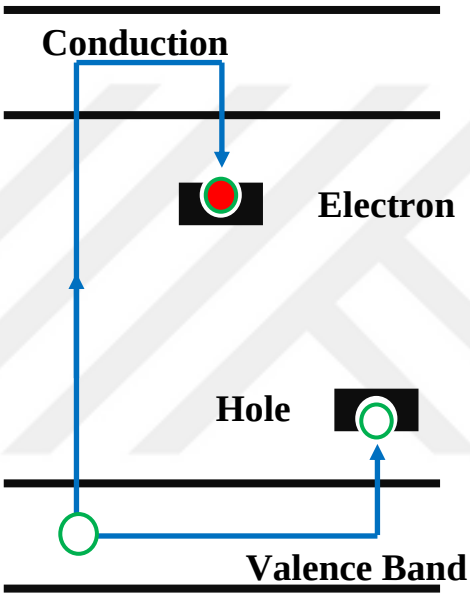

Figure 2.12 Schematic energy level diagram of a phosphor exhibiting thermo-luminescence. [25]

2.23 Radiation dosimeter

Radiation dosimetry is fundamental in the applications of the radiation and radioisotopes, especially in Medical Physics. Radiotherapy are X-rays, gamma radiation and beta particles; however, high-energy electrons, heavy particles and neutrons [33].

Dosimetry in Medical Physics involves the patients and phantom dosimetry as well as the occupationally exposed personnel and the environmental monitoring in hospitals.

The radiation field is defined as purpose is to evaluate the safety or the efficiency of the radiation exposure, and other cases the aim is to verify the observation of the radiation protection regulation [34, 35].

2.24 Thermoluminescent dosimeter

Thermoluminescent dosimeters (TLDs) are solid semiconductors that, when heated irradiate, will emit visible light that is related to the amount of radiation to which they were initially exposed. Because of this capability, TLDs have many uses in the medical field. One of the main uses of TLDs is can be to determine actual doses administered at either skin or body cavities of patients undergoing radiation therapy [36, 37].

2.25 Radiation Dosimeters

Radiation dosimeter is a device instrument or system that evaluates, either directly or indirectly the quantities exposure, atmosphere, absorbed dose, or their time derivatives (rates) or related quantities of ionizing radiation. A dosimeter along with its meter is referred to as dosimetry system [38, 39].

2.26 Thermoluminescence Dosimeters (TLD)

TLDs are solid crystalline materials that are semiconductors. Semiconductors, in general, conduct electricity only under certain conditions compared to conductor that fully conduct electricity or to those materials that do not conduct any electricity at all, which are called insulators (e.g. plastic). Semiconductors conduct electricity depending on the temperature. At absolute zero they do not conduct. However, as temperature increases the conductivity of TLDs also increases. The process of thermoluminescence of TLDs takes place by initially absorbing radiation, whose energy is trapped in the TLD. The trapped energy can then be released if the TLD is

exposed to heat. The energy that is released is delivered in the form of visible light [40].

A more detailed analysis of this process can be understood by looking at a TLD at the atomic level. In semiconductors, electrons can be located at discrete energy bands. The two main bands we are concerned with are the valence band and the conduction band. Electrons are distributed spatially in the TLD crystal depending on their energy either in the valence or in the conduction band.

At the valence band are those electrons that are located at the lattice sites of the crystal. Electrons that have stuffiest energy to migrate through the crystal will be located at the conduction band. To make an electron located at the valence band jump to the conduction band, enough energy must be provided to overcome the energy gap of l 0electron Volts (eV) between the bands.

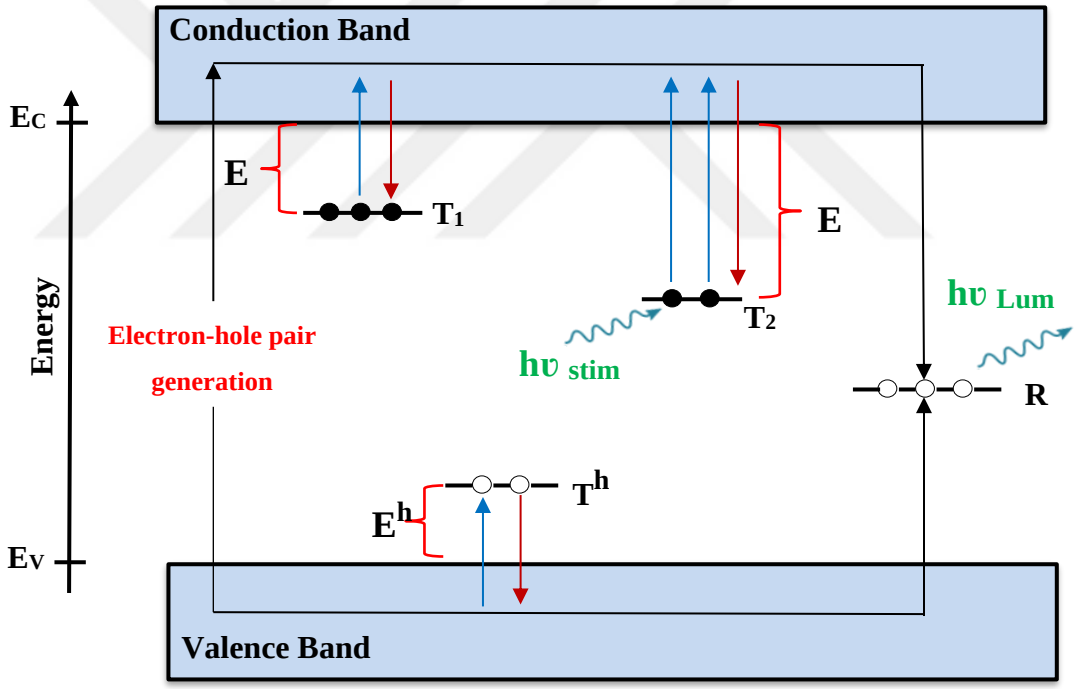

Figure 2.13 Basic concepts of Thermoluminescent. [49]

When TLDs are exposed to radiation, electrons located in the valence band are excited and jump above the band gap and into the conduction band, leaving behind an empty space or hole. This creates what is called an electron-hole pair (Figure 2.13).

On the energy borderlines of the valence band and the conduction band with the energy gap, two additional energy sites are present. The excited activator site is located close to the lower energy border of the conduction band. Electrons located in the conduction band tend to drift to this site. On the other hand, the ground activator site is close to the upper energy limit of the valence band and positive holes will drift to this site. Electrons and holes will stay in place along to TLD is not heated. I the TLD is heated, then the electron will move out of the conduction band and rejoin the positive hole, emitting visible light. The visible light emitted is proportional to the amount of radiation, to which the TLD was exposed to. A photomultiplier tube (PMT) converts the light into an electrical charge that is sufficiently amplified as to be read by a meter or a computerized system. The electrical charge, usually expressed in nano-coulombs, is also considered to be proportional to the radiation or the absorbed dose that initially exposed the TLD. The light intensity or brightness produced by combining an electron and a positive hole is known as a glow peak. Glow peaks can be fully or partially resolved. The integration of all the glow peaks produced by the sum of all electrons escaped is known as a (TL) glow curve. Both glow peaks and glow curves can be observed in the output that is created by a TLD Reader and the computerized system that is attached to the reader. Charge that is sufficiently amplified as to be read by a meter or a computerized system. The electrical charge, usually expressed in Nano coulombs (nc), is also considered to be proportional to the radiation or the absorbed dose that initially exposed the TLD Reader and the computerized system that is attached to the reader.

An additional factor to consider when heating a TLD is the probability of escape of the electron from the conduction band. This probability of escape is related to two main parameters. One is the energy level in which the electron was trapped and the second is the amount of heat that is imparted. Electrons that are more deeply trapped will require a higher temperature to be released than electrons that are in shallow traps, which will require lower temperature.

$$\boldsymbol{p = \alpha \times Exp^{\frac{-E}{KT}}} \tag{2.1}$$

This probability of escape can be expressed mathematically using the Randall Wilkins theory (Equation 2.1), where p is the probability of escape of the electron, $\boldsymbol{\alpha}$ is a constant and called the frequency factor, E is energy depth of the trap, k is the Boltzmann constant and T is the temperature in degrees Kelvin. From this formula, we can ascertain that for a given T, the probability of escape, p, will decrease with increasing energy to the energy depth of the trap. But at any given E, increasing T will also increase p. Thus, it can be observed that if T is not increased when energy is high, the probability of escape is reduced.

Glow peaks are produced depending on the energy depths at which the different electrons were trapped. A maximum glow peak will occur at the highest cutoff temperature that was applied to the element. This highest glow peak will release a certain amount of visible radiation depending on the rate at which heat is applied to the TLD. If temperature is increased at a high rate per unit time, then the glow peak will have a smaller height in the distribution of that peak. If the temperature rate increase is less per unit time, then the height of the glow peak will be larger. Therefore, when reading TLDs it is important to consider the appropriate linear heating rate in order to achieve an optimum light emission and an effective integration of all glow peaks under the glow curve.

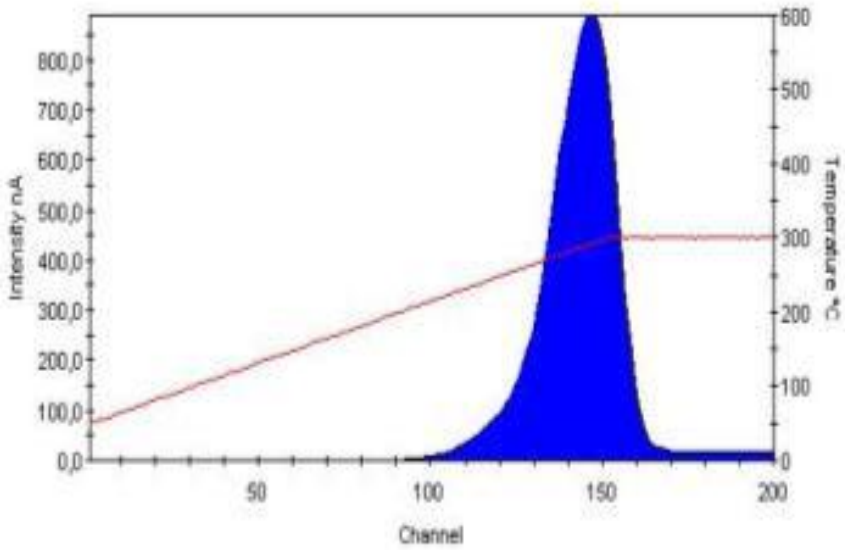

Figure 2.14 Glow curves of the TLD-100 chips

2.27 *in-vivo* Dosimeters (IVD)

In vivo measurements were used in a long time for cancer treatment. Because it was possible to calculate the dose delivered to patient easily, currently in vivo dosimetry is common to evaluate a quality and quantity of dos that used for each treatment such as the critical organizations (lens, eyes, etc.). In vivo dosimetry (1VD) can also be useful to monitor the irradiation for special techniques for example total body irradiation or total skin electron irradiation etc. Dosimetric examinations in special or anthropomorphic phantoms loaded with dosimeters and irradiated in the same conditions as patients can also be useful to check the validity of special techniques prior to routine practice, to point out problems related to suboptimal treatment planning systems [42].

2.28 Clinical Application in *in-vivo* Dosimetry

A potential aim of using IVD is to compare the doses derived from the detectors to a phantom that placed on human's body, with the theoretical values, as evaluated by the Treatment Planning System (TPS). However, the accuracy of the calculation the dose to the skin is problematic. More ambitious aim of in vivo dosimetry is to check the target dose, in order to verify the correct delivery of irradiation [41, 42].

CHAPTER 3

EXPERIMENTAL PROCEDURES

The materials, equipment's and experimental procedures utilized in this work are described below.

3.1 Equipments

3.1.1 LiF: Mg,Ti:

LiF: Mg is an alkali halide with 8.2 atomic number. It is generally used to employees checking. It can be found in many systems explicitly chips, powders. LiF: Mg (TLD100) which is particularly using is a LiF crystal doped with titanium and magnesium, in which Titanium used to increase the number of luminescence centers, and Magnesium used to increase number of the traps in the lattice, as show in (fig 3.1). TLD100 is formed by melting lithium fluoride, lithium cryolite, magnesium fluoride and lithium titanium fluoride. Because of that have a high sensitivity, and its emission peak goes to 400nm wavelength mean blue region in electromagnetic spectrum [43].

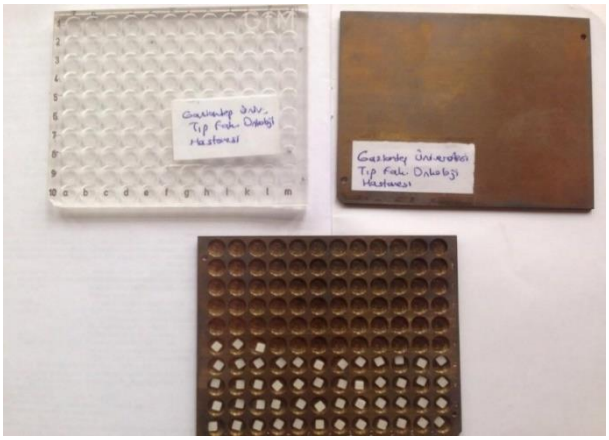

Figure 3.1 TLD Dosimetres used in the study

By temperatures function the TL intensity have many glow peaks, in the traps of the crystal of LiF, at first exponentially raised a maximum range and then producing a peak. Because of founding traps glow peaks are produced, and made a graph, which known as glow curve. The structure of material, and a number of the impurities, are two important effect that number of the peaks and the height of crystals glow curve depend on.

Table 3.1 The advantage and disadvantage of (TLD-100) dosimetry

ADVANTAGES	DISADVANTAGES
TLDs have availability of readers from many productions.	The signal that produce is read only one time, because it's delete all reading data during the progression.
They are reachable in many forms.	It is easy to lose the analysis.
They are emitted dos as tissue.	Loss of TL signal due to fading.
Because of their small size they can be used as a point dose measurement.	TLDs have different sensitivities-Calibration that is not good to found to accurate measurements.
The range of dose are so large.	TLDs are sensitive to light.
The ratio of dose that used is not depend on its reaction.	TLDs need the Annealing proses, because its storage is not stable.
TLD s could reused in different time, because of annealing procedures, ether they absolutely damaged.	Same time TLD or its impurity might scrape, because of Spurious TL signals that cusses by dirt or humidity.
The price of TLD s is decreased Due to their reusability.	Its sensitivity changed when irradiate by large amount of dose, thus another time need annealing proses.
It does not require any wet chemicals, because of the read-out is quick.	It is not suggested for beam calibration.

When a TLD material heated, a small part of the incident ionizing radiation will absorb and measure a dose. In which the ratio between the TL light that emitted per unit mass, and the absorbed dose is create intrinsic efficiency of the TLD. Who is found to be 0.039% for TLD100, with the rest dose 99.6% nearly, thus converted to thermal radiation [44].

3.1.2 The Computed tomography (C.T™)

Is computed tomography (CT) of the body more commonly known as a CT or CAT scan, is a diagnostic medical test by using special x-ray equipment to help detect a variability of conditions and diseases, CT scanning is painful, fast, correct and non-invasive. Computed tomography, which, traditional x-rays, produces multiple images or pictures of the inside of the body. The cross-sectional images created during a CT scan can be reformatted in multiple planes, and can even generate three-dimensional images. As show in (fig 3.2). These images can be viewed on a computer monitor, printed on film or transferred to a CD or DVD.

Figure 3.2 Computed Tomography CT imaging

Computed tomography (CT) images use to inner organs, bones, soft tissue and blood containers typically provide greater detail than traditional x-rays, using specialized equipment and capability to create and interpret CT scans of the body, radiologists can more easily diagnose problems such as cancer, cardiovascular disease, infectious

disease, appendicitis, trauma and musculoskeletal disorders in many ways. Different body parts absorb the x-rays in varying degrees. It is this critical difference in absorption that allows the body parts to be distinguished from one another on an x-ray film or CT electronic image.

C.T™ scanner is premeditated specifically for oncology departments, the system topographies a unique 85 cm windbag that helps positioning difficult to image exams such as breast, mantle, and fat patients, and the position of laser with three points one on the rooftop and two on the opposite walls for patient. The CT image displays both high density tissue such as bone, and low-density tissue such as lung and soft tissue [45].

3.1.3 Heating proses (Oven)

We use oven for annealing proses, the batch of fifty TLDs as obtained was initially annealed according to procedure described below. The thermal treatment is essential procedure for re usability TLDs, and the ideal annealing parameter can depend on the actual material and instrument. Annealing procedures consisted of two steps high temperature, and flowed by fast cooling. The TLDs were first placed in the annealing tray, the tray used for annealing was made of steal and the TLDs were put in the TLDs containers (cups) and then in the tray, each cup holds one TLD. (Fig 3.3 the oven and TLD s in a steal cups). The steal tray was heated to 240 ^{o}C oven for 10 min; this was flowed by 10 min cooling. This procedure should be done before and after each measurement [45, 46].

a. b.

Figure 3.3 a. Oven, b. TLD 100 in steal cups

3.1.4 The ART phantom Randophantom

The ART phantom is used as a model of a human being. The phantom is shaped like a human, and is composed of materials that are equivalent to the different tissues and different organs that are found in a referee human person (Fig 3.4). The ART phantom is used in this study to make dose comparisons between the TPS software and the TLD-100 measurements. The ART phantom is used in medical physics, as well as in health physics for radiation protection purposes of that it serves as a tool in determining the effective dose equivalent to a human without the need to expose an actual person. By averaging the individual doses to organs and tissues with weight factors that are associated to their radio sensitivity, it leads to the determination of an effective dose equivalent for the phantom that can be applied to the human body.

The ART phantom is assembled in slices that are each 2.5 cm thick, and is held together by stalemate rods and tensioning handles at both ends. A metal base is placed at the bottom of the ART Phantom so it can stand vertically (Fig 3.4). Each slice is made up of materials that are equivalent to soft tissue, bone or lung tissue depending on the relative position of the slice. The ART phantom has an equivalent of 34 slices starting with slice number 1 on top of the head of the ART Phantom. Every slice has

incorporated a grid of holes with plugs placed appear in a 3 X 3 ems pattern the plugs and holes transverse the slice perpendicularly along the long axis of the phantom. The plugs can be customized so they can accept different forms and shapes of TLDs [45, 46].

Figure 3.4 The ART Phantom (Rondo Phantom)

3.1.5 A Linear Accelerator (LINAC)

A linear accelerator (LINAC) revises high energy of x-rays to destroy cancer cells and conform to a tumor's shape, while parsimonious nearby to normal tissue. LINAC s working will checked by the physicist, to ensure its proses, while given perfect treatment.

LINAC systems are used exclusively for radiotherapy treatment. Systems are the daily workhorses for conservative radiation therapy departments, which can also be provisionally adapted to perform radiosurgery. LINACs are usually mounted egocentrically. An isocentric technique, where all beams used in a treatment have a

common focus point. Thus, in the case of centric LINAC, all of its movements arise around an axis that runs through the center. In this way, if the center of the target area in the patient's body is moved to coincide with the isocenter, then all signals of the machine will remain centered with the target.

The LINAC can deliver 2 photon energies: 6 and 12 Megavolts (Mv), as well as five different electron energies (6, 9, 12, 15, and 18 MeV). By using these different forms of energy, radiation can be directed precisely towards the position of a benign or malignant tumor for the elimination of cancer cells, while at the same time ensuring that healthy cells around the neighborhood of a tumor are not irradiate. The (fig 3.5 is show LINAC)

The linear accelerator like radar uses microwave technology to accelerate electrons, in a part of the accelerator called the "wave guide", the electrons collide with a heavy metal target to produce high-energy x-rays. The shape of the high energy x-rays is depended on shape of the patient's tumor and the modified beam that absorbed to the patient's tumor. The beam may be shaped either by blocks that are located in the head of the machine or by a collimator that combined to the head of the machine. Lasers are used to make sure the patient is in the proper position, because the moveable may cuss mistake in treatment. There was a part of the accelerator, known as a gantry, which can be revolved around the patient by different angle when radiation dos irradiated [46].

There was a staff of radiation oncologist who's prescribes the appropriate and quality of treatment volume and dosage. The medical radiation physicist determines how to deliver the prescribed dose and calculate the amount of dos and time it will take the patios to deliver that dose.

Figure 3.5 Linear Accelerator (LINAC)

3.2 Thermoluminescence Reader

The automatic TLD reader type PCL3 was used in this experiment. Is designed for the evaluation of different TLD material in the form of rods, chips or powder. In one loading, it can read 80 dosimeters with varies type of TLDs. Depending on the type of material used, the system can be applied for dose levels ranging from environmental monitoring to radiation therapy and beyond [47]. TLD reader can read individual TLD elements including rods, ribbons and chips. The system is attached to a personal computer where it interfaces with proprietary soft are developed by the Harshaw Corporation. The TLD reader (Figure 3.6) incorporates a single tray where the different forms of TLD elements can be read. It also includes a linear heating system and a PMT tube that measures the light output from the TLDs. The amplified signal is sent through the reader's electronics and transferred to the software for proper analysis of the output.

Figure 3.6 TLD Reader Harshaw TLD System 3500

The Time Temperature Profile (TTP) is user defined in three segments. Preheat, Acquire, and Anneal, each with independent times (Pre-read anneal: adjustable 0 to 1000 Sec, Linear ramp: adjustable from 1 ^{o}C to 50 ^{o}C per second, Post-read anneal: 0 to 1000 Sec) and temperature (reading of anneal:room temperature to 200 ^{o}C, Post-read anneal: up to 400 ^{o}C). (Fig 3.7) shows the profile of the typical time temperature. For improving the low-exposure reading accuracy and to extend planchet life, the 3500 provides for nitrogen to flow around the planchet . Through the elimination of oxygen in the salinity, flow of nitrogen eliminates unwanted TL signal caused by the oxygen. Nitrogen is also directed through the photo-multiplier tube (PMT) chamber to eliminate moisture caused by condensation.

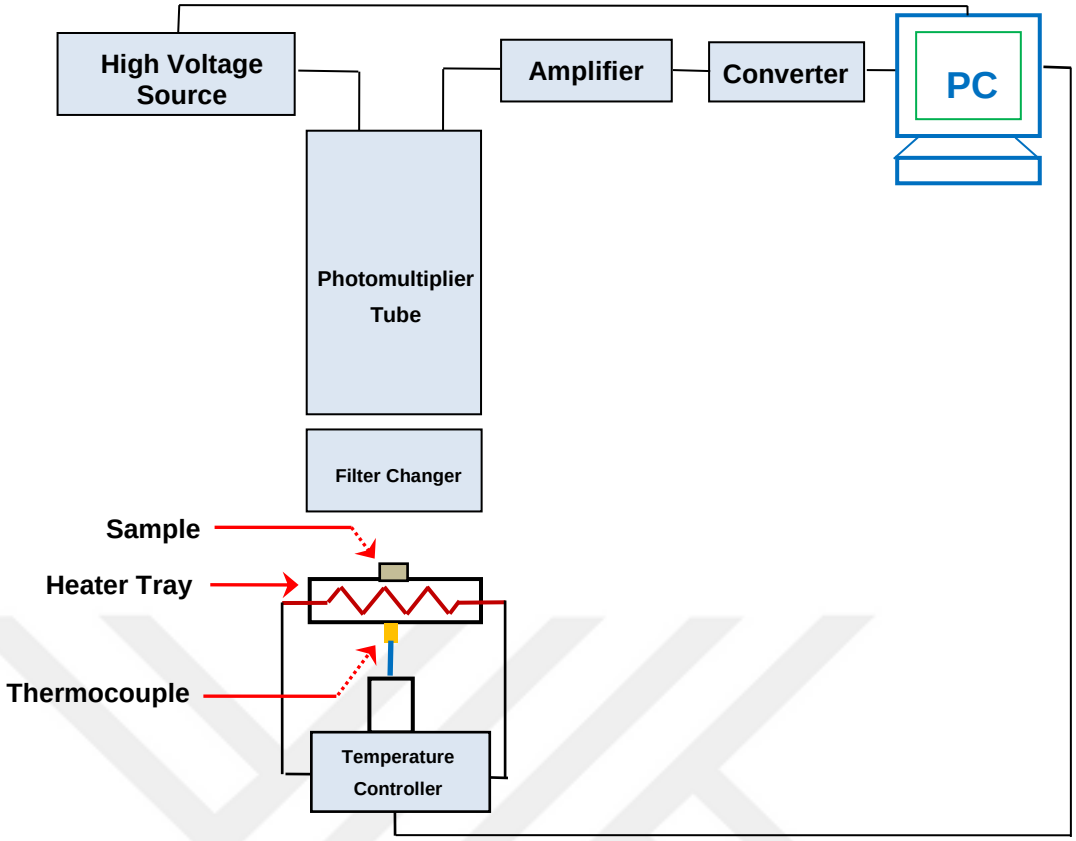

Figure 3.7 Basic block diagram of TL reader [41]

In order to reduce the potential emission of light that is not produced by the heating process of the TLDS (noise), and to eliminate any possible interferences between the PMT and the location of the plan Chet where the TLD is located, a flow of nitrogen at room temperature is passed over the PMT. The nitrogen flow for this study was preset at 5 standard cubic feet per hour (S CFH) with the gas regulator for the nitrogen tank set at a pressure of 200 Kilo-Pascal [50].

3.3 Calibration of TLDs

It is strongly recommended to achieve a separate calibration for each radiation beam quality. If the TLDs can be identified, a calibration factor could be given to each dosimeter and it is necessary to monitor the individual factors in different time. In repetition, having a large number of dosimeters is possible to save a part of them for the purpose of calibration. The readings of the patient dosimeters can then be converted in dose by comparing their response to the ones of the calibrated dosimeters [50].

3.4 Element Correction Coefficient (ECC)

Because all TLD-1OO's are not exactly same, even within the batch in which they were produced, a correction factor must be introduced for every TLD element. A (TLD) can have some variation in materials and in size, compare to other TLDs. The response from the TLD will also be characteristic of that TLD and will be different from the response of other TLDs. Because of these differences, we must ensure the proper correction factor for each TLD element can be used for future exposure of that specify TLD.

The correction factor utilized is called the Element Correction Coefficient (ECC) which is determined by the following equation:

$$\boldsymbol{ECC = \frac{\langle Q \rangle}{Q_i}}$$

Where $\langle \boldsymbol{Q} \rangle$ is the average integrated charge in nano coulombs of all the calibrated TLDs, and $\boldsymbol{Q_i}$ is the total integrated charge for a specify TLDj, also in nano coulombs [48].

3.5 The Reader Correction Factor (RCF)

A correction factor must also be established for the type of reader used. Just as with the TLDs, every TLD reader has its own characteristics. TLD readers can vary from one to another, and therefore we must take into account the inherent characteristics of that TLD, if the system is automatic or manual, and the dependence on the inert gas utilized to reduce the noise of the PMT in the reader. The RCF is described mathematically as:

$$\boldsymbol{RCF = \frac{\langle Q \rangle}{L}}$$

Where: $\langle \boldsymbol{Q} \rangle$ is the average integrated charge in nano coulombs of all the calibrated TLDs, and $\boldsymbol{L}$ is the exposure given to the TLDs that are being calibrated [48].

3.6 Annealing procedure

The batch of fifty TLDs as obtained was initially annealed according to procedure described below.

The thermal treatment is essential procedure for re-usability TLDs, and the ideal annealing parameter can depend on the actual material and instrument. Annealing procedures consisted of two steps high temperature, and flowed by fast cooling, as describe the procedure in the user manual [50].

The TLDs were first placed in the annealing tray, the tray used for annealing was made of steal and the TLDs were put in the TLDs containers (cups) and then in the tray, each cups hold one TLD. The steal tray was heated to 400 $\overset{o}{C}$ oven for 60 min; this was flowed by 10 min cooling. This procedure should be done before and after each measurement.

CHAPTER 4

EXPERIMENTAL STEPS AND RESULT

4.1 Methods

In this study phantom has been thought as whole brain cancer so the treatment volume is whole cranium, 3B treatment plan and system used to generate radiotherapy plan. The up taking dose of brain, critical organ like (lens, eye) doses, also chiasma dose (TLD-100) has been used and compared to system of treatment plan.

4.2 Simulation

RT treatment plan is very complex issue in order for the treatment to be established safely right way, the areas that equine thus should be situated and measure that equine should be taken. For such reason in the simulator human body (The Alderson Randophantom) spine position.

Figure 4.1 CT Image for Randophantom

Whole critical organs and all defined brain ICRU according to so 62 crates as, BT section have been outlined. The right and left 2 opposite parallel fields used. Eyes and lenses protected.

4.3 Treatment plan boundaries

Anterior Boundary: In front of frontal lope.

Posterior boundary: skin of occipital lope.

Superior boundary: vertex Inferior boundary: including skull base, temporal lobe inferior extension and cribriform.

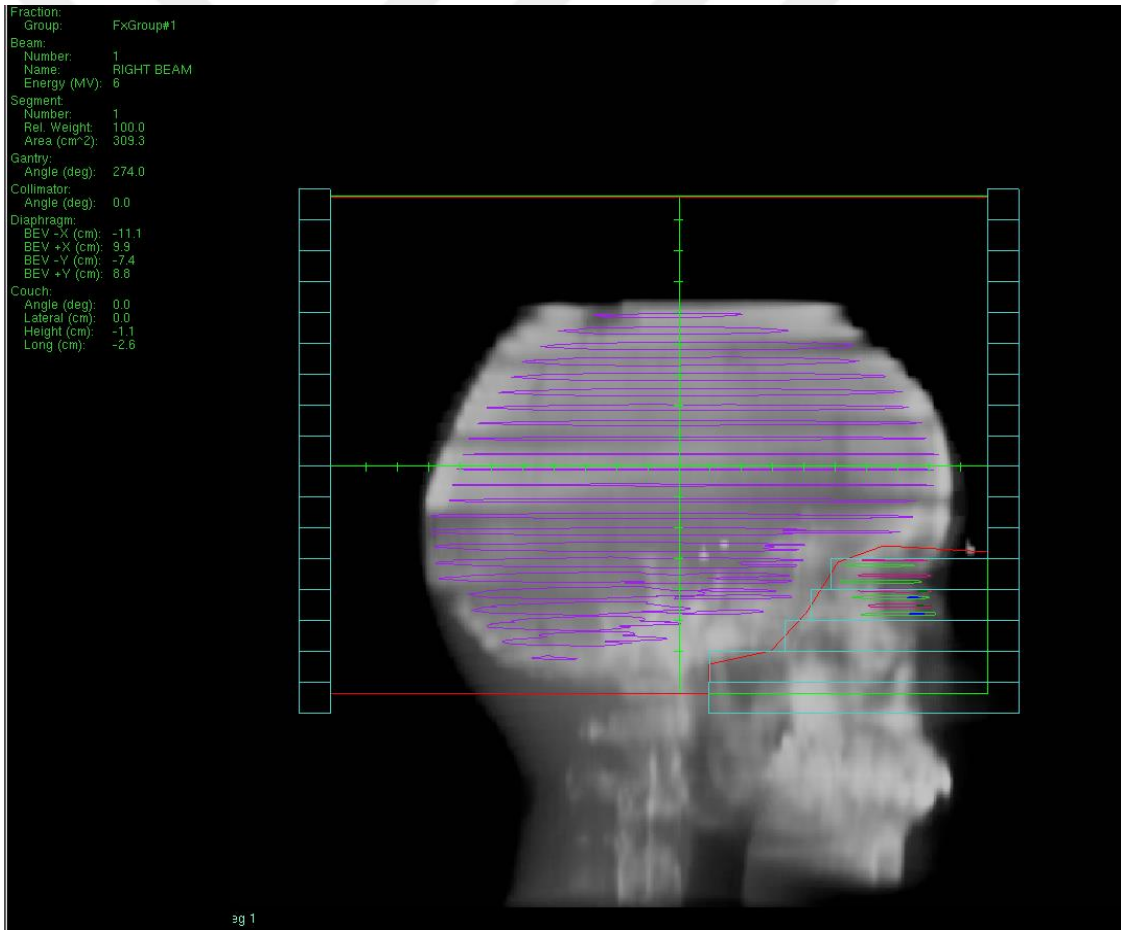

Figure 4.2 3D DVH for whole brain of RF

4.4 Linear acceleration quality control tests

Before standing application of 3KRT, according to AAPM task Grace Pho and 53 numbered reposts.

The required quality control test of the treatment machine has been done on a routine basis reading dose metric measures the produced radiation yield of the SSD=100 cm and 10*10 cm, area dimension, the maximum dose depth (d masks) fore 6MV photon energy = 1.5 cm, 1MU= 10 Gray

In such manner calibrated and substituted for the calibration RW3 solid phantom has been used. 0.6 cc farmer tip room and dimension has been done according IAEA technical. Reports series (TRS) 398(38) numbered dose protocol trams work.

TLD 100 chips calibration and section Before passing to dose calculation by TLD100 requiring some procedures to be done including showing the sensitivity of TLD chip ECC (element correction coefficient) and taken from the redder nc given species photo tube current radiation adsorption quantity in the cycle transformation coefficient foundation usage (RCF) reader calibration factory).

Because not all TLD chips have been produced in the same precision despite same quantity radiation and absorption they release different quantity of light during radiation. Thus, to eliminate such differences every chip given weight factor such factor is (ECC).

TLD-100 chips in the TLD oven 400 ^{o}C has been heated up to 1 hour, after that every chip irradiated in such manner every chip uptake 50 cGy dose in LINAC and red each TLDs in TLD redder with WINRIMS program. We get first our data the ECC value founded and 20 pieces in presume boundaries selected and brought ready for measurement

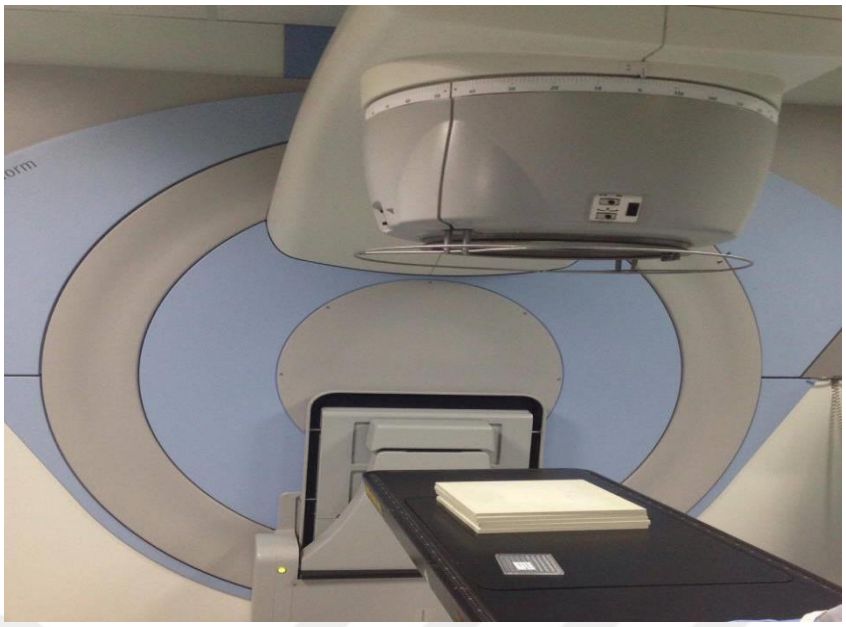

Figure 4.3 Irradiation of TLD

And find RCF for TLD that have an ECC near to each other and nearly to one, as show in (table 4.1) above, as highlighted. And find RCF for all of TLD s that chose, use these formulas:

$$\boldsymbol{ECC_j = \frac{TL_E}{TL_j} = \frac{TLD_{average}}{TLD}}$$

$$\boldsymbol{RCF = \frac{Q}{L}}$$

$\boldsymbol{Q}$: Calibration Dosimeter

$\boldsymbol{L}$: Radiation Quantity ($\boldsymbol{gu}$) (The Exposure to the TLD)

$$\boldsymbol{Q = ECC_i \times Q_j}$$

Table 4.1 Calibration of TLD-100's (LiF:Mg:Ti)

All Datas	Imax	ECC=(TLE/TL)
A1	261	1.049808429
A2	258	1.062015504
A4	266	1.030075188
A5	274	1
B1	271	1.011070111
B2	265	1.033962264
B3	260	1.053846154
B5	297	0.922558923
C1	232	1.181034483
C2	274	1
C4	280	0.978571429
C5	268	1.02238806
D1	273	1.003663004
D2	257	1.06614786
D4	278	0.985611511
E1	298	0.919463087
E2	276	0.992753623
E3	286	0.958041958
E4	282	0.971631206
F1	298	0.919463087
F3	273	1.003663004
F4	258	1.062015504
G2	281	0.975088968
G4	266	1.030075188
H1	301	0.910299003
H2	274	1
H3	283	0.96819788
H4	273	1.003663004
I1	250	1.096
I3	288	0.951388889
I4	279	0.982078853
K1	282	0.971631206
K2	285	0.961403509
K4	272	1.007352941
L1	274	1
L2	275	0.996363636
L3	287	0.954703833
L4	265	1.033962264
M1	280	0.978571429
M2	263	1.041825095
M3	270	1.014814815
M4	272	1.007352941
Average	273.8824	1
RCF	5.477647	

After that all 20 TLD-100 chips that chose before are annelid, mean heated in oven anther time as 400 ^{o}C, and then TLD are ready to irradiate. Then located in different reign in whole brain of randophantom hole sillies. As show in (fig 4.4).

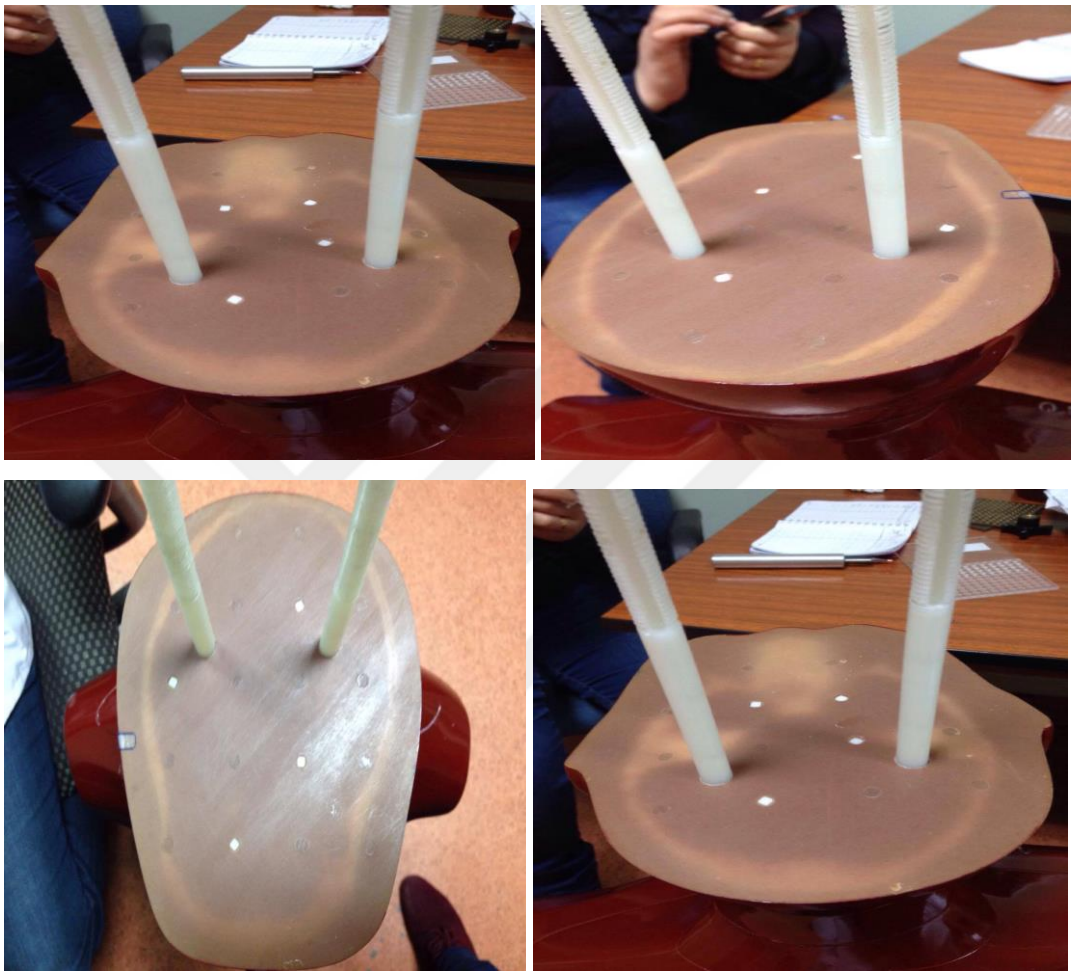

Figure 4.4 Putting TLD in holes of sillies in Randophantom's Brain

Put ART randophantom in (LINAK), to irradiate for two side right and left of head, each side irradiate by 150cGy. Mean 300cGy for both sides. And by use the equations that used before and doss equation we get a new data as show in (table 4.2)

$$ECC_j = \frac{TL_E}{TL_j} = \frac{TLD_{average}}{TLD}$$

$$RCF = \frac{Q}{L}$$

$\boldsymbol{Q}$: Calibration Dosimeter

$\boldsymbol{L}$: Radiation Quantity ($\boldsymbol{gu}$) (The Exposure to the TLD)

$$\boldsymbol{Q = ECC_i \times Q_j}$$

$$\boldsymbol{Dos = \frac{TL\ Reading\ (nc)}{RCF\ Factor(^{nc}/_{cGy})}}$$

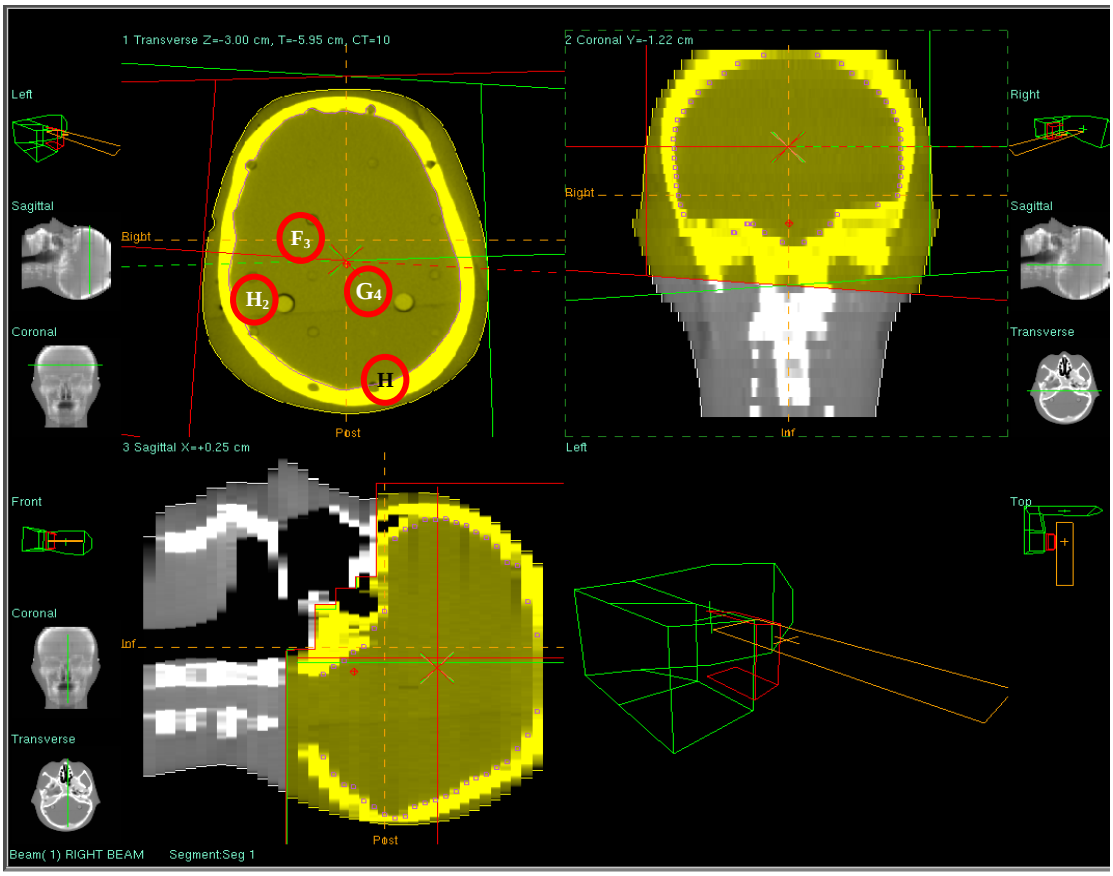

Figure 4.5 Dose for different points in the Whole Brain

Table 4.2 Measured Dose to TLD- 100's in the ART Anthropomorphic Phantom

Total Brain	TLD Peak	ECC	Dose (cGy)
B1	342	1.011	295.33679
B2	441	1.033	298.37618
C2	477	1	298.49812
C5	468	1.0222	292.86608
D1	334	1.003	290.94077
E2	336	1	295.25483
F3	414	1.003	296.13734
G4	368	1.03	290.22082
H2	298	1	295.63492
H4	416	1.003	297.56795
Avg.	389.4		
RCF	1.298		
Kizma	TLD Peak	ECC	Dose (cGy)
A4	357	1.030075188	297.2522898
A5	322	1	292.4613987
Avg.	339.5		
RCF	1.13166667		
Right Lens	TLD Peak	ECC	Dose (cGy)
I1	20	1.096	15.40832
K4	27	1.007352941	20.801233
L1	31	1	23.882897
L2	24	0.996363636	18.489985
Avg.	25.5		
RFC	1.13166667		
Left Lens	TLD Peak	ECC	Dose (cGy)
L4	31	1.033962264	23.882897
M2	30	1.041825095	23.112481
M3	47	1.014814815	36.209553
M4	33	1.007352941	25.423729
Avg.	35.25		
RFC	1.13166667		

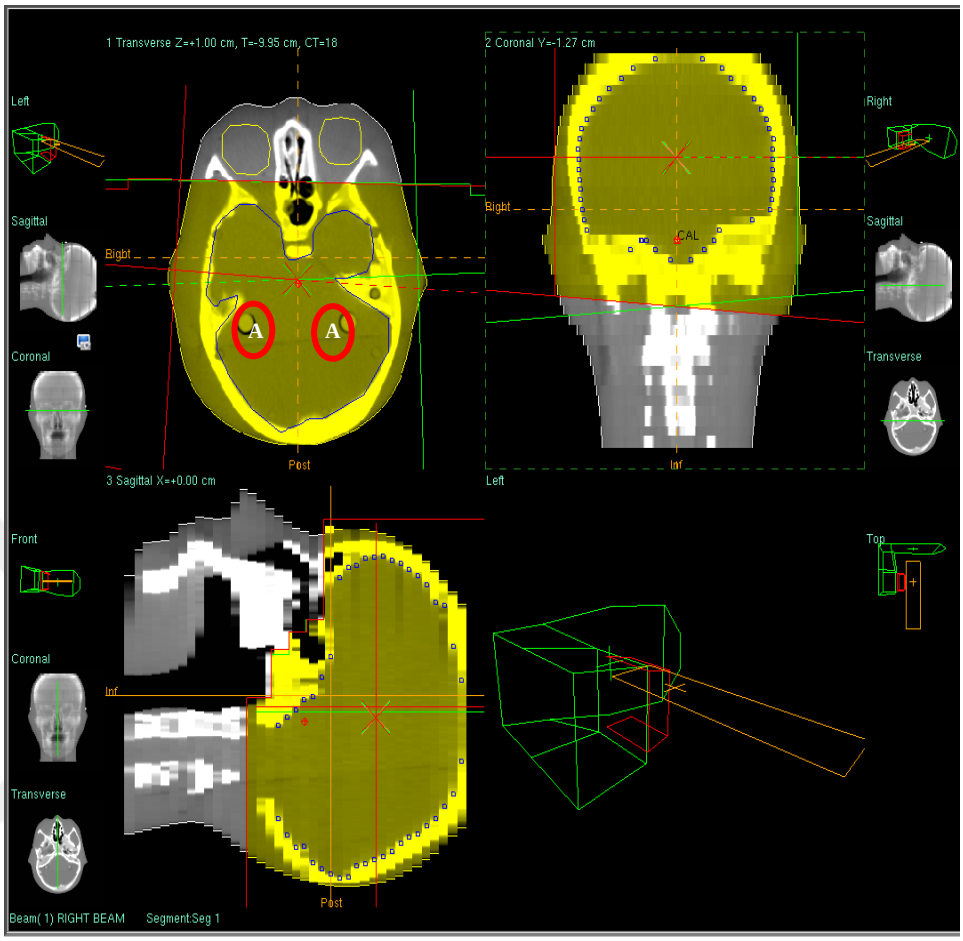

Figure 4.6 Dose for Two points in the Kiazma

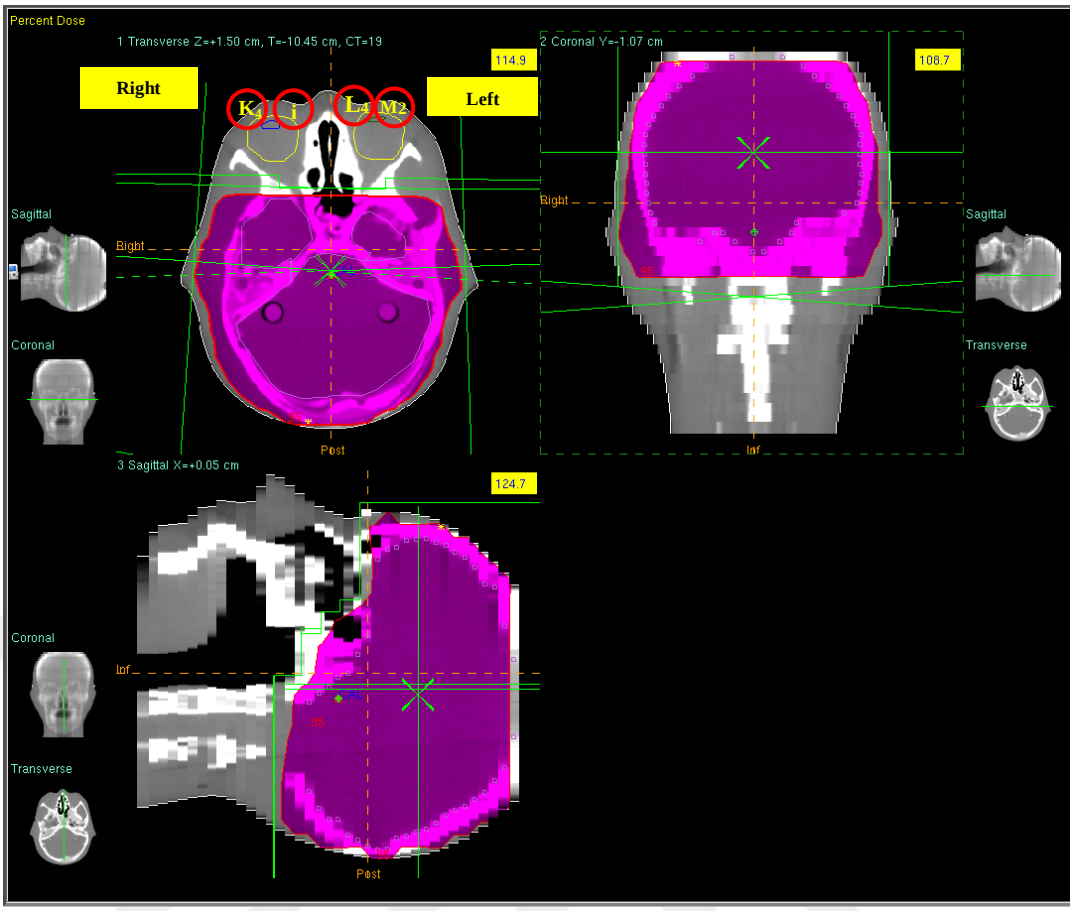

Figure 4.7 Dose distribution for different points in the Right & Left lens

With the usage of EPID providing the Tips to be determined on the randophantom, the port fill defined in the TPS with drawn thus treatment plan has been set.

Each TLD-100 chips irradiated by 300 cGy, each side of phantom 150 cGy, in opposed side and red every TLD in TLD reader, with winram program and calibrated each TLD-100 chips and find ECC and RCF for each chip.

Table 4.3 Basic Statistical Measures for TLD- 100, TPS and their Difference for whole brain.

Points	Position	Planning Dose cGy	Measure(RF) dose cGy	Difference
B1	Total brain	295.34	299	-0.01
B2	Total brain	298.37	311	-0.04
C2	Total brain	298.49	319	-0.06
C5	Total brain	292.86	318	-0.08
D1	Total brain	290.94	314	-0.07
E2	Total brain	295.25	315	-0.06
F3	Total brain	296.13	313	-0.05
G4	Total brain	290.22	313	-0.07
H2	Total brain	295.63	308	-0.04
H4	Total brain	297.56	308	-0.03
I1	Right leans	15.40	15	……
K4	Right leans	20.8	18	0.11
L1	Right leans	23.88	18	0.27
L2	Right leans	18.48	18	
L4	Left leans	23.86	17	0.05
M2	Left leans	23.11	18	0.27
M3	Left leans	36.21	30	0.20
M4	Left leans	25.42	17	0.27
A4	Kiazma	297.25	307	0.03
A5	Kiazma	292.46	308	0.05

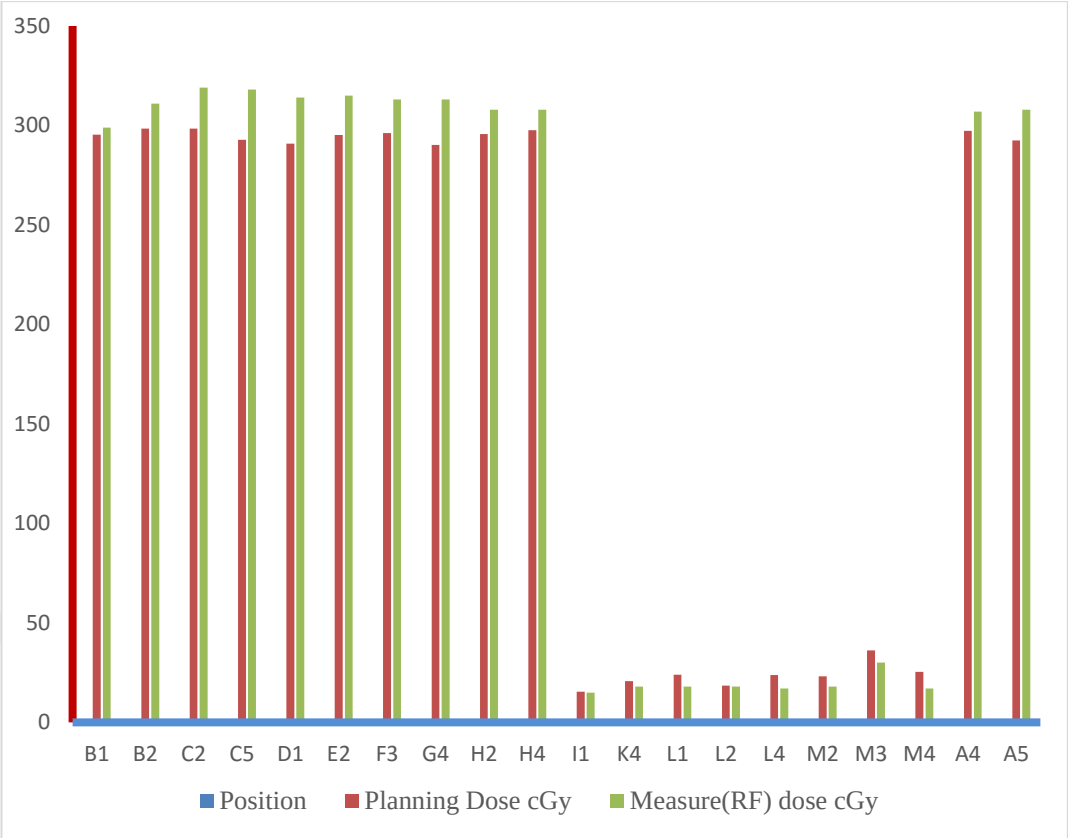

Figure 4.8 Difference between planning dose and measure (RF) dose

As show in table there was a small difference between the planning dose, and measured dose in (RF), by tis data we have a graph that show amount of dos that each part emits. And there is a graph which show the different parts of brains tissue will take different amount of dose, and in figures to for example as show in (Fig 4.4) the brains region take nearly same amount dos of (TPS), and the right and left side of head which include right and left lens as show in (Fig 4.6) have a different amount dose and this point is so important because as studded before the critical organ must not emit the same amount dose that irradiate because may cause to loss straight senses.

PrecisePLAN Release 2.16 - 28.76 Page 1 of 1 CPU ID: 1609248338

Patient ID	000000166	Print Date	05-FEB-2016 11:44
Patient Name	RF^Unknown	Image Dataset	RF
Plan: 0	UNSAVED CHANGES	Plan Date	05-FEB-2016 11:44
Signature			

Key	Structure (2500 pts LIVE)	Plan	Min Dose(%)	Max Dose(%)	Mean Dose(%)	Total Vol (cc)
	Brain	Current	95	119	105	957.2
	R.Eye	Current	4	48	13	7.5
	L.Eye	Current	4	41	12	7.1
	R.Lens	Current	4	9	9	0.2
	L.Lens	Current	4	9	9	0.1

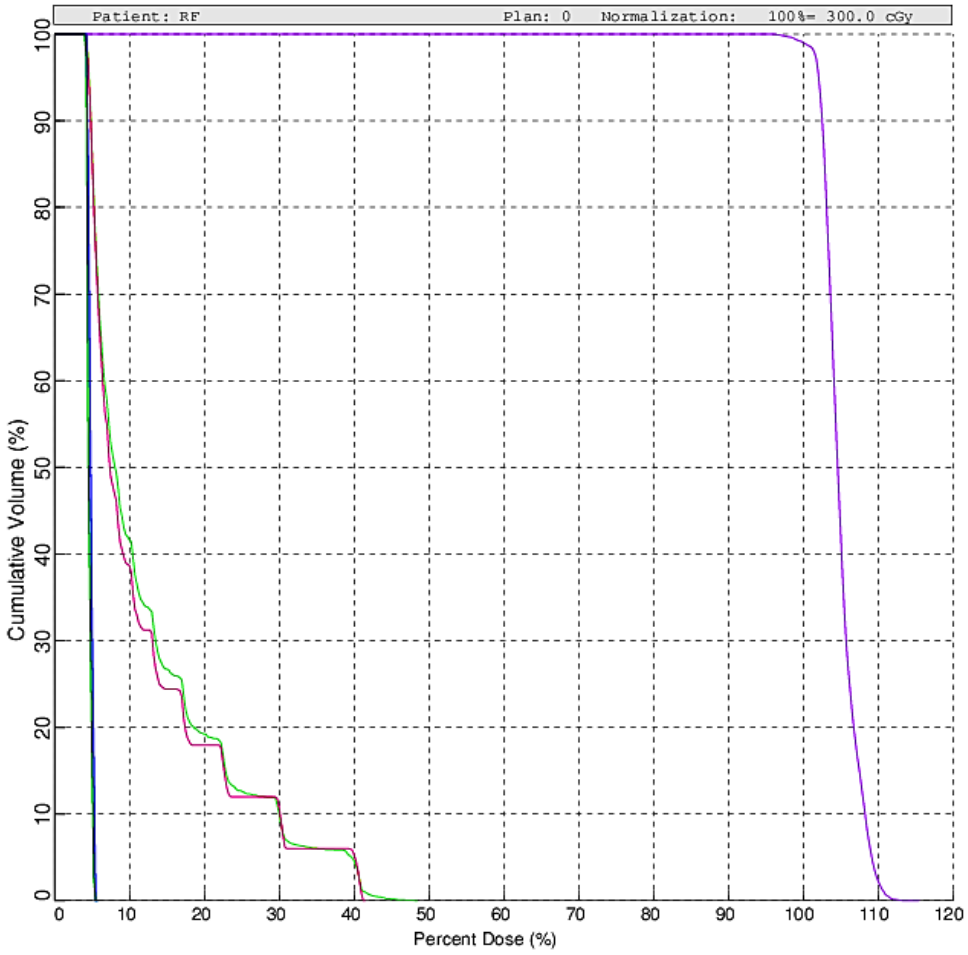

Figure 4.9 Amount of doses for different part of brain

CHAPTER 5

CONCLUSION

The aim of this study was to determine the TLD smaller to human's tissue, by use the dose calculation by a three-dimensional treatment planning system (TPS) used in radiation therapy differ by more than 5 % from actual measured dose calculations. It is the resolute by medical physicist to deliver the applicable dose to a specific brain tumor, and at the same time for the dose to have a negligible effect on healthy tissues surrounding the tumor tissues. To measure the dose, Lithium Fluoride (LiF:Mg:ti) thermoluminescent dosimeters (TLD's) were used. The distribution of a radiotherapy treatment involves many consecutive, complex steps of preparation, imaging, calculation and patient (RF) positioning. Each step me be subsidize to an indecision of delivered dose.

In-vivo dosimetry is the checker that during the patient treatment. TL dosimeters most commonly used in medical applications are LiF:Mg, exactly in vivo dosimetry ,because of their tissue equivalence. They are available in many forms (e.g., powder, chips). TLDs have to be annealed to remove the remaining signal before they are used. To originate the absorbed dose from the TLDs a few correction factors have to be applied, such as energy correction coefficient (ECC), reader Correction Factor (RCF),

Fifty-one TLD's were exposed to 50 cGy. The dose response from TLD system by less than 5% from the set dose on the Linear Accelerator (LINAC) radiation therapy system. In Addition, the dose distribution of the residual values of each TLD system were analyzed. There is a possibility of a small partiality, which can be credited several variables. One is the irregular calibration of the TLD reader. The TLD reader is used for academic purposes and it is not used on a routine basis. After proper calibration of 20 TLD- l00 s, they were inserted into an ART phantom at the different point in whole brain

region. The ART phantom had gone through an initial pretend patient treatment planning where a simulated tumor was determined in the pubic region. After exposure

of the phantom to a prescribed dose of 300 cGy, the 20 TLD dose response function was compared to the calculated dose determined by the TPS at the location of each TLD. It was found at the isocenter or the pivot point at which each side will give the dose of 150 cGy.

We can conclude that the measured dose was different from the calculated dose obtained from the TPS. These differences however, do not seem to be significant. Showing that the larger differences took place at about 37 % of the TLD locations. Which include the critical organ eye, lens.

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