

**ANALYSIS OF ANGULAR DEPENDENCIES BETWEEN OSLD
AND TLD- COMPARISON OF ITS IN-VIVO SURFACE DOSE
MEASUREMENTS FOR POST MASTECTOMY BREAST
IRRADIATION**

A THESIS SUBMITTED TO THE
**D. Y. PATIL EDUCATION SOCIETY
(DEEMED TO BE UNIVERSITY), KOHLAPUR.**



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DOCTOR OF PHILOSOPHY
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BY

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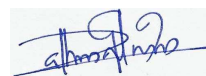
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DECLARATION

I declare that the thesis entitled “**Analysis of angular dependencies between OSLD and TLD- comparison of its in-vivo surface dose measurements for post mastectomy breast irradiation**” submitted for the degree of **Doctor of Philosophy (Ph.D.) in Medical Physics, Centre for Interdisciplinary Research, D. Y. Patil Education Society (Deemed to be University), Kolhapur** is completed and written by **Mr. Ratheesh K.E**, under the supervision of **Dr. K. Mayakannan**, has not before made the basis for the award of any degree/diploma/other related heading of this or any other university in India/any other country/examining body of to the best of my knowledge. Further, I assert that, I have not dishonoured any of the requirements under copyright and piracy/cyber/IPR act amended by UGC from time to time.

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LIST OF ABBREVIATIONS

AAA	Anisotropic Analytical Algorithm	IAEA	International Atomic Energy Agency
AAPM	American Association of Physicists in Medicine	IBA	Ion Beam Application
APBI	Accelerated Partial Breast Irradiation	ICDs	Implantable Cardio-vertex Defibrillators
Al ₂ O ₃	Aluminum Oxide	ICRU	International Commission on Radiation Units and Measurements
BCS	Breast conservative surgery	IEC	International Electrotechnical Commission
CaSO ₄	Calcium Sulphate	IGRT	Image Guided Radio Therapy
CaF ₂	Calcium Fluoride	IMRT	Intensity Modulated Radiation Therapy
cc	Cubic centimetre	IVD	In-vivo Dosimetry
CCD	Couple Charged Device	KeV	Kilo electron Volt
cGy	centi Gray	kPa	Kilo Pascal
cm/s	Centimetre per Seconds	LCD	Liquid Crystal Display
Co-60	Cobalt 60	LD	Luminescent Dosimeter
CT	Computer Tomography	LED	Light Emitting Diode
CW	Chest Wall	Li ₂ B ₄ O ₇	Lithium Borate
DNA	Deoxyribo Nucleic Acid	LiF	Lithium Fluoride
EPID	Electronic Portal Imaging Device	LiGa ₅ O ₈	Lithium Gallium Oxide
ECC	Element Correction Coefficient	LINAC	Linear Accelerator
EHT	Extra High Tension	LS	Light Source
g/cm ³	Gram per cubic centimetre	MeV	Mega electron Volt
Gy	Gray	Mg	Magnesium
HD	High Definition	MLC	Multi Leaf Collimator

mm	Millimetre	RF	Radio Frequency
MOSFET	Metal-oxide Semiconductor Field Effect Transistors	RFA	Radiation Field Analyser
MRM	Modified Re constructive Mastectomy	RPLD	Radio Photo Luminescent Dosimeters
ms	Millisecond	RT	Radio Therapy
mSv	milliSievert	SAD	Source-to-Axis Distance
MU	Monitor Unit	SBRT	Stereotactic Body Radiation Therapy
MV	Mega Volt	SCF	SupraClavicular Fossa
nA	Nano Ampere	SRS	Stereotactic Radio surgery
nC	nano Coulomb	SSD	Source to Surface Distance
nm	nanometre	TBI	Total Body Irradiation
OAR	Off Axis Ratio	TG	Task Group
OD	Optical density	Ti	Thallium
ODS	Optical Data Storage	TL	Thermo Luminescence
OSL	Optically stimulated Luminescence	TLD	Thermo Luminescent Dosimeter
OSLD	Optically stimulated Luminescent Dosimeter	TPS	Treatment Planning System
PDMS	Polydimethylsiloxane	TSEI	Total Skin Electron Irradiation
PETCT	Positron Emission Tomography - Computed Tomography	UV	Ultraviolet Radiation
PMRT	Post Mastectomy Radiotherapy	VMAT	Volumetric Modulated Arc Therapy
PMT	Photo Multiplier Tube	WHO	World Health Organization
PSD	Plastic Scintillation detectors	ZnGa ₂ O ₄	Zinc Gallate
PSL	Photo stimulable Luminescence	3DCRT	Three Dimensional Conformal Radio Therapy
PTV	Planning Target Volume		

ABSTRACT

Breast cancer remains the most common cancer among women worldwide, with a high mortality rate in India largely due to late diagnosis, which is often attributed to a lack of awareness and inadequate screening. Radiotherapy is a key treatment option for breast cancer, particularly after surgery, and plays a crucial role in improving survival rates. However, breast irradiation can lead to both acute and chronic skin toxicities, such as erythema and desquamation, resulting from uneven dose distribution. Accurate surface dose measurement is essential for managing these adverse reactions.

This study aims to compare the angular dose response of Thermoluminescent Dosimeters (TLD) and Optically Stimulated Luminescence Dosimeters (OSLD), evaluated in both phantom and clinical settings, to determine their effectiveness in measuring surface dose during post-mastectomy radiation therapy. The research involves 100 post-mastectomy breast cancer patients, where TLD and OSLD are used to assess surface dose, helping to manage skin toxicities more effectively. The study revealed that OSLD measurements exhibited a maximum discrepancy of 3.65 for field sizes between 20 cm² and 30 cm², with a minimum variation of 1.27. In contrast, TLD measurements showed a higher maximum discrepancy of 4.10 and a minimum of 1.55 over the same field sizes. These findings suggest that OSLD offers slightly better precision and measurement stability, likely due to the greater sensitivity of Al₂O₃:C compared to LiF:Mg,Ti. Furthermore, the maximum dose deviation between central and off-axis dosimeters was 1.2 for OSLD and 3.43 for TLD, indicating that OSLD provides superior stability and lower deviation in clinical settings, where precision is critical.

The research emphasizes the practical application of these dosimeters in measuring surface doses during modified radical mastectomy (MRM) breast irradiation. A comparative analysis of the dosimeters highlights variations in dose measurements based on placement and radiation beam entry. Detailed reports systematically tabulate these variations, offering insights into the potential impact of dosimeter positioning on accurate dose assessments.

In terms of dose variation, TLDs exhibited a maximum deviation of 7.33% and a minimum of 0.38% from the planned dose, with an average difference of 3.85%. OSLDs, on the other hand, showed a maximum deviation of 6.82% and a minimum of 0.04%, with an average difference of 3.15%. The maximum dose deviation between central and off-axis measurements was 6 cGy for OSLDs, while TLDs had a range from 5 cGy to 2 cGy, suggesting OSLDs provide more consistent performance in agreement with treatment plans.

The study aims to thoroughly evaluate the uniformity of surface dose distribution during MRM breast irradiation, particularly after mastectomy. Luminescent dosimeters, such as TLDs and OSLDs, are highlighted as transformative tools in radiotherapy, allowing real-time monitoring and refinement of dose distribution. This enables clinicians to adjust treatment plans as needed, improving patient outcomes and enhancing quality of life post-treatment. In conclusion, the use of luminescent dosimeters, as demonstrated in this study, offers a significant advancement in the precision of breast cancer radiotherapy. By focusing on surface dose uniformity following MRM surgery, clinicians can optimize treatment strategies, reduce side effects, and improve the overall effectiveness of breast cancer care.

CHAPTER 1

INTRODUCTION

- 1.1. GENERAL INTRODUCTION
- 1.2. LINEAR ACCELERATOR (LINAC)
- 1.3. RADIOTHERAPY IN BREAST CANCER
- 1.4. DOSIMETRY IN RADIOTHERAPY
 - 1.4.1. IONIZATION CHAMBERS
 - 1.4.2. RADIOGRAPHIC FILMS
 - 1.4.3. LUMINESCENT DOSIMETERS (LD'S)
 - 1.4.4. DIODES
- 1.5. IN VIVO DOSIMETRY
- 1.6. LITERATURE SURVEY
- 1.7. CHOICE OF THE TOPIC WITH REASONING
- 1.8. REFERENCES

CHAPTER 1

INTRODUCTION

1.1. GENERAL INTRODUCTION

Radiation therapy, a medical discipline, employs ionizing radiation to treat malignant diseases (1-3), primarily targeting cancer. Ionizing radiation functions by causing damage to the DNA (Deoxyribonucleic acid) in cancerous tissue, resulting in cellular demise. Radiation therapy can offer a curative option for certain localized cancer types, and it can also serve as a palliative treatment in cases where a cure is unattainable, aiming for the control of local disease or relief of symptoms (4). As a localized treatment, radiotherapy precisely delivers focused ionizing radiation to the tumour site, thereby eliminating cancer cells and inhibiting their ability to proliferate.

Radiotherapy is divided into two main categories:

Teletherapy: Radiation is administered from a safe distance (Figure 1.1) using standardized equipment such as Tele cobalt and Linear accelerator (2, 3).

Brachytherapy: Radiation is applied directly to or near the treatment area using either invasive or non-invasive techniques (2, 3).

Linear accelerators, for instance, produce a stream of electrons that are accelerated through a wave guide, increasing their energy from KeV to MeV range. These high-energy electrons then collide with a tungsten target, producing therapeutic x-rays that are utilized in medical treatments (5, 6).

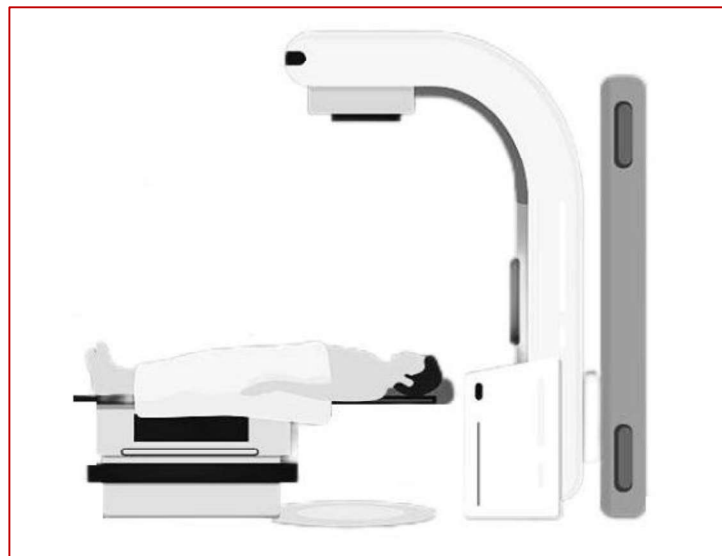


Figure 1.1. Teletherapy, Schematic representation (iStockphoto LP, Stock illustration ID 635911932, 2016)

1.2. LINEAR ACCELERATOR (LINAC)

LINAC is a device that uses high-frequency electromagnetic waves to accelerate charged particles such as electrons to high energies through a linear tube (5,6). The high-energy electron beam itself can be used for treating superficial tumours, or it can be made to strike on a target to produce x-rays for treating deep-seated tumours. Medical LINAC can accelerate the electron from a kinetic energy ranging from 4 MeV to 25 MeV.

LINACs are usually mounted isocentrically and the operational systems are distributed over five major and distinct sections of the machine, Gantry, Gantry stand, Modulator cabinet, Patient support assembly (i.e. treatment table), and Control console. A schematic diagram of a typical modern medical LINAC is shown in Fig.1.2. The diagram provides a general layout of a LINAC's components; however, there are significant variations from one commercial machine to another, depending on the final electron beam kinetic energy as well as on the particular design used by the manufacturer. The main beam forming components of a modern medical LINAC are usually grouped into six classes: (i) Injection system; (ii) RF power generation system; (iii) Accelerating wave guide; (iv) Auxiliary system; (v) Beam transport system; (vi) Beam collimation and beam monitoring system.

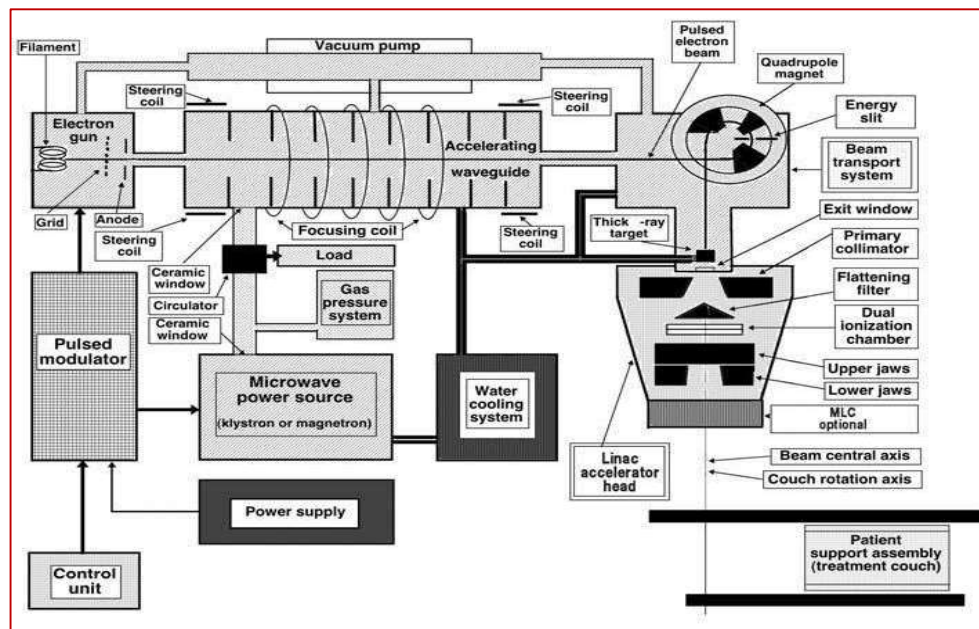


Figure 1.2. Schematic Diagram of Medical Linear Accelerator Parts (Nikki Martiniz.2016, Radiotherapy)

1.3. RADIOTHERAPY IN BREAST CANCER

Breast cancer is one of the most prevalent and challenging malignancies affecting women worldwide (7). It is a complex disease with various subtypes, and its treatment strategies have evolved significantly over the years. A modified radical mastectomy (MRM) serves as the primary treatment approach for women diagnosed with locally advanced breast cancer (8). In addition, certain women with early-stage breast cancer may opt for a mastectomy for various reasons, including cosmetic preferences, the desire to potentially avoid radiation therapy, or due to the presence of a genetic mutation that increases the risk of future breast cancer. A mastectomy involves the complete removal of the entire breast and is often accompanied by the sampling of axillary lymph nodes to assess the extent of the disease (9). Among the treatment modalities, radiotherapy plays a pivotal role in improving patient outcomes, particularly by reducing the risk of local recurrence after surgical intervention (10-12). As a result, research into radiotherapy for breast cancer has become an integral part of the ongoing efforts to enhance both the effectiveness and safety of treatment (13, 14).

In breast cancer, radiotherapy is employed after surgery (breast-conserving surgery [BCS] or mastectomy) to reduce the risk of tumor recurrence in the breast or nearby lymph nodes (10-12) (Figure 1.3).



Figure 1.3. Breast Irradiation field arrangements

The efficacy of radiotherapy in breast cancer management has been established over decades, but ongoing research endeavors continue to fine-tune the approach. This introduction serves as a prelude to an exploration of the diverse dimensions of research

in radiotherapy for breast cancer. The scope of these investigations extends from optimizing radiation techniques to improving patient selection, minimizing treatment-related side effects, and enhancing the overall patient experience (7, 9).

1.4. DOSIMETRY IN RADIOTHERAPY

The radiation dose is referred to as the "absorbed dose" indicating the quantity of radiation energy that gets deposited within the unit tissue (15-18). The absorbed dose is a critical factor in assessing the impact of radiation on both tumours and healthy tissues. An increased absorbed dose to tumours leads to a higher rate of radiation-induced cell death and, consequently, an improved chance of a successful cure (16-20). Conversely, a higher absorbed dose to normal tissues increases the probability and severity of unwanted and potentially harmful radiation-induced side effects. So there should be a balance between the treatment of the disease and safety of the nearby normal organs (21-23).

Radiation dosimeters and dosimetry systems are available in various configurations, and they utilize a range of physical effects for the storage and retrieval of dosimetric information (24-27). The four most frequently employed radiation dosimeters include:

- i) Ionization chambers
- ii) Radiographic films
- iii) Luminescent dosimeters (LD's)
- iv) Diodes

1.4.1. IONIZATION CHAMBERS

Ionization chambers are gas filled detectors working on the principle of ionization of medium when radiation incidents (28-30). A basic ionization chamber comprises a metallic cylinder containing a thin axial wire enclosed within a glass envelope, filled with an inert gas. The set-up involves applying a high potential difference between the cylinder and the wire electrode. In this configuration, the wire functions as the anode, while the cylinder serves as the cathode. Different types of chambers are used in RT, e.g. cylindrical chambers, and parallel plate chambers etc., (Figure 1.4). Generally, ionization chambers used for Absolute dosimetry in RT (12). These chambers are calibrated from a reference standard laboratory (12).

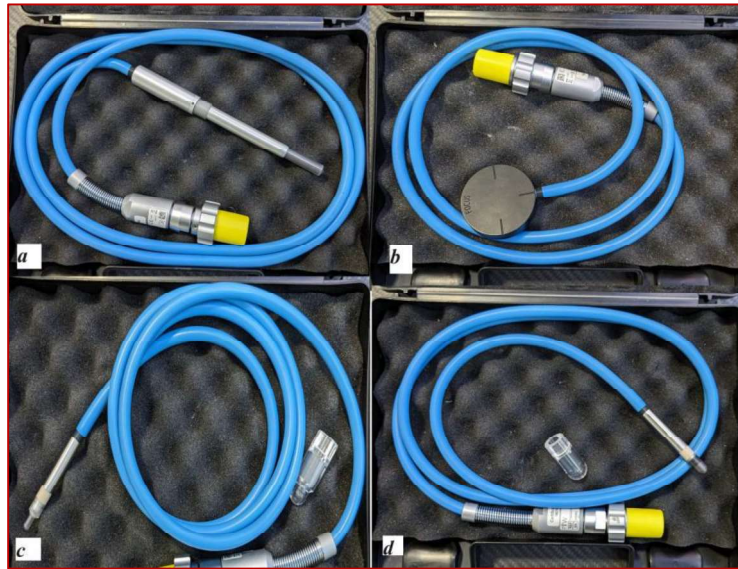


Figure 1.4. Different Ion chambers: a) Farmer type 0.6cc volume chamber, b) parallel plate (0.35cc), c) Pin point chamber (0.03cc), and d) Semi flex 0.125cc

1.4.2. RADIOGRAPHIC FILMS

Radiographic films are devices capable of undergoing a permanent visible color change when exposed to radiation. This change in color results from a reduction in visible light passing through the developed film, causing it to appear 'greyed.' The extent of light reduction serves as a quantification of the film's 'blackness' or 'optical density' (OD) (31). A fundamental assumption in film dosimetry is that the film's optical density accurately reflects the dose it receives. Modern radio chromic film dosimeters come in various formats, offering precise dose measurements. These detectors are highly valuable in medical radiation dosimetry due to their relatively energy-independent dose response and the automatic development of radio chromic film products (11).

1.4.3. LUMINESCENT DOSIMETERS (LD'S)

In luminescent dosimetry (LD), the light signal generated by radiation is assessed and measured to determine the radiation dosage. This process relies on the radiative recombination of electrons and holes at luminescent centres within the LD material (32-34). Various factors affect the luminescence efficiency of an LD, including the quantity of traps and other defect centres encountered by secondary electrons in their path, and the nature of their interactions within the luminescence centre. The luminescence characteristics of solid materials, such as optically stimulated

luminescence dosimeters (OSLDs), and thermoluminescence dosimeters (TLDs) are extensively employed in clinical applications, particularly in clinical dosimetry (Figure 1.5) (34). This preference is attributed to their compact sizes, superior spatial resolution, and versatile dose-response range capabilities. These dosimeters are well-suited for in-vivo dosimetry applications.



Figure 1.5. TLD and OSLD nano dots

1.4.4. DIODES

In diode dosimetry, the incoming ionizing radiation produces electron-hole pairs across the diode. The minority carriers, namely electrons on the “p” side and holes on the “n” side, undergoes diffusion towards the pn junction (Figure 1.6). Carriers located within a distance of about one diffusion length from the junction edge can reach it before undergoing recombination (12,13). Subsequently, these carriers are propelled across the junction by the applied potential and are quantified by the Electrometer (10).

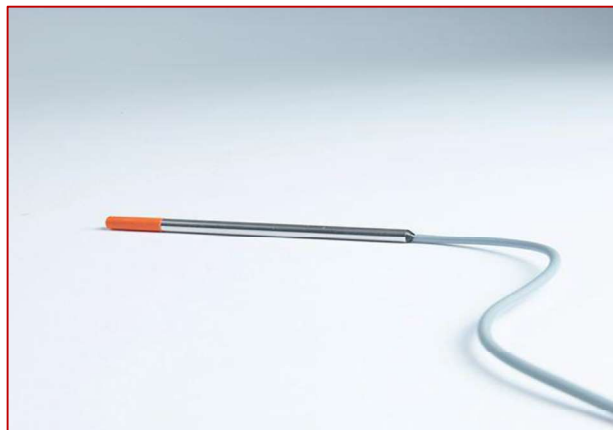


Figure 1.6. Diode detector (IBA dosimetry catalogue; Product catalog 2022).

1.5. IN VIVO DOSIMETRY

In-vivo dosimetry (IVD) refers to a radiation measurement obtained during patient treatment, providing data regarding the absorbed dose in the patient (10) as represented in the Figure 1.7.

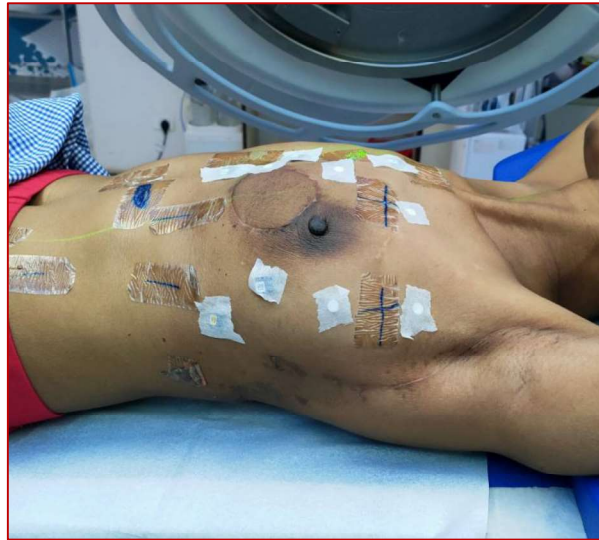


Figure 1.7. Dosimeter placed for in-vivo dosimetry

This definition suggests that an IVD system should be capable of identifying errors arising from equipment malfunction, inaccuracies in dose calculation, patient positioning discrepancies, and alterations in patient anatomy (11). In-vivo dosimeters can be categorized into two main types:

Real-time detectors: Real-time detectors possess the capability to measure the total dose administered during a treatment session. Moreover, they are fundamentally equipped to measure the time-resolved intra fraction dose delivery, including 4D dose variations, or dose rate. This additional functionality can offer valuable insights in certain situations. Diodes, metal-oxide semi-conductor field effect transistors (MOSFETs), plastic scintillation detectors (PSDs), and electronic portal imaging devices (EPIDs) are some of real time dosimeters (12,13).

Passive detectors: These detectors do not yield immediate measurements; instead, they necessitate a finite amount of time, ranging from minutes to hours, for their read-out process. TLDs, OSLDs, RPLDs, implantable MOSFET detectors, and films (radiographic and radio chromic).

Each of these detectors requires some finite time for analysis after irradiation.

Both types of dosimeters typically undergo calibration by comparing their response to that of a calibrated ionization chamber within a known radiation field (31-33).

Once the detectors have been calibrated and the necessary correction factors have been determined for their application in specific treatment techniques, several procedures need to be executed before an IVD system can be clinically applied, and clinical decisions can be made based on IVD measurements. Initially, the detector system must undergo testing on phantoms under tightly controlled conditions, aiming to closely simulate the actual treatment process. These comprehensive end-to-end tests serve as a validation of the entire IVD chain, ensuring the accuracy of all steps in the measurement procedure, including the application of the correct calibration and correction factors (32-34).

The applications of in in-vivo dosimetry include the measurement of skin dose and dose to the organ at risk near to the treatment area. Knowledge of the skin dose is necessary to restrict the dose to an organ at risk located near the skin's surface. It is also essential to ensure that an adequate dose is delivered to the treatment area, particularly in treatments involving the chest wall or total skin electron irradiation (TSEI).

Out of field in in-vivo dose measurements are frequently necessary for estimating the dose received by organs at risk during radiotherapy. These organs may include the contra lateral breast, eye lens, and scrotum. Additionally, such measurements are vital for assessing the dose received by implanted electronic devices such as pacemakers and implantable cardio verter-defibrillators (ICDs).

Skin dose measurements require the utilization of a thin dosimeter with a precisely known thickness. This thin dosimeter is essential because it allows for accurate assessment of the radiation dose absorbed by the skin surface. The known thickness of the dosimeter ensures that the measurements are reliable and can provide valuable information regarding the radiation exposure to the skin during radiotherapy or diagnostic imaging (11,21,28).

1.6. LITERATURE SURVEY

Both TLD and OSLD are used to measure the outputs for photon and electron beams within the current clinical radiotherapy energy ranges (12). The influence of the angle of radiation beam incidence on TLD and OSLD has been primarily examined

through simulation models. These angular entries of radiation beam because an unpredictable dose deposition to the body surface, which has to be monitored. The first concern is absorbed dose to the skin, which can result in deterministic effects such as erythema, epilation in severe cases, and necrosis (1). The second concern is the risk of stochastic effects (risk of cancer induction). The risk depends on the radiation dose absorbed by radiosensitive organs and tissues in the body. Measurement of these doses is difficult. A brief summary of the literature review is provided in Tables 1.1 and 1.2.

Table 1.1. Literature survey on Breast Irradiation

Sl no:	Concept	Method	Aim	Result	Ref / Year
1	The mechanism of post mastectomy radiation therapy(PMRT)	Describe the potential adverse effects of PMRT	Review of PMRT application and its effectiveness	There is a reduction in relapse rates and overall mortality	35/2023
2	Hypo fractionated RT for treatment of early breast cancer	Comparative study on conventional RT regimen to Hypo fractionated RT	To reduce the Treatment duration without affecting the overall treatment benefit	Hypo fractionated radiotherapy is safe and effective for patients with early breast cancer.	36/2013
3	Application of RT in Breast Cancer	Retrospective analysis of RT courses in Breast treatment	Evaluating the omission of RT versus omission of endocrine therapy for favourable-risk patients	Use of tumour genomic to identify appropriate patients for omission of radiation	37/2021
4	Literature reviews on Breast Cancer	Arbitrary studies with the highest level of evidence or the highest number of most recent meta-analysis	Literature reviews on Breast cancer diagnosis and treatment	Radiotherapy remains an important cornerstone of breast cancer therapy	38/2021
5	Discussion of various RT approach to Breast Treatment	Literature reviews on utility of RT in breast cancer management	To discuss on the modern techniques of RT in the breast cancer treatment	Considerations of increasing use of neo adjuvant chemotherapy and trend towards shorter course of RT	39/2010

Table 1.1. Literature survey on Breast Irradiation (cont...)

Si no:	Concept	Method	Aim	Result	Ref / Year
6	Pre RT test to predict the toxicity of radiation	Identifying patients to apply treatment modification to minimize side effects and improve the life quality	Proposing personalized treatments to improve the outcome	Developed a test, which allows predicting these secondary effects before starting the treatment	40/2014
7	Retrospective analysis of RT sequentially or Concomitantly to CDK4/6i	Retrospectively analysed 43 patient received RT along or after CDK4/6i	Safety and Feasibility of Radiation Therapy Combined with CDK 4/6 Inhibitors	Optimize multi-modality treatment in a large population of patients with advanced breast cancer	41/2023
8	To Introduce Short course of RT in APBI	Short course of RT trial performed on 61 patient with Breast cancer	To analyse the benefit of APBI over conventional RT	APBI is an attractive treatment option for patients with low-risk breast cancer	42/2023
9	Effect of RT after MRM surgery on 10-year recurrence and 20-year breast cancer mortality	Meta-analysis of individual data for 8135 women randomly assigned to RT after MRM.	Comparison of RT versus non RT after MRM on long survival.	Radiotherapy reduced both recurrence and breast cancer mortality	43/2019
10	Skin surface dose for whole breast RT using personalized breast holder	The dose measurement with EBT3 film and TLD were taken on Rando phantom with different PERSBRA set-up.	Comparison with Various RT Techniques and Clinical Experiences for a lower surface dose during the RT	The effectiveness of PERSBRA has been analysed and reported	44/2022

Table 1.2. Literature survey on Luminescent Dosimeters

Sl no:	Concept	Method	Aim	Result	Ref / Year
1	Surface dose measurement in OAR	^{60}Co and 6MV LINAC Comparison.	Surface dose comparison with the help of TLD	^{60}Co give more surface dose but Linac provide more uniformity.	45/ 2021
2	Clinical use of Luminescent dosimeters	Interaction of different LD in Radiation	Implementation of OSLD and TLD in clinical usage	Recommendation on implementation of LD	46/ 2015
3	Measurement of near by organ dose	Various method of dose estimation including OSLD and TLD	Concern on dose estimation of out of field organs	Recommendation on implementation of OAR dose estimation	47/ 2006
4	Comparative study of different TLD materials	Algorithm based dose estimation and comparison	Comparison of different family of TLD materials	Almost identical behaviors of compared TLDs	48/ 2002
5	Annealing and dose response of TLD	X ray based study of different TL materials	TL dose response to annealing process	Application of TLD in X rays	49/ 2006

Table 1.2. Literature survey on Luminescent Dosimeters (cont...)

Sl no:	Concept	Method	Aim	Result	Ref / Year
6	Lung Dose measurement in 3DCRT of Left- Sided Breast Cancer	Phantom based comparative study of TPS and actual dose during delivery	To rule out the variation of lung dose from TPS calculated to actual delivery through LD dosimetry	TPS generally overestimated doses compared to TLD measurements due to incorrect beam modelling	50/2021
7	2D spatial radiation dosimetry based on optically stimulated luminescence (OSL) phenomena	prototype dosimeters in form of flat and flexible sheets made of a polymer (PDMS), with the embedded OSL active grains	To determine the response of 2D OSL prototype silicone foils, stimulated with the blue LEDs (470 nm) and read out using the CCD camera system	direct measurements of the 2D dose distribution using the OSL method and self-developed optical set-up were verified	51/2020
8	Characterization and use of OSLD for in in-vivo dosimetry in head and neck IMRT	sensitivity, reproducibility, dose-rate dependence, beam quality dependence, output factor measurement and comparison of two bleaching techniques	Nature and the use of OSLD as an in in-vivo dosimetry tool for head and neck IMRT	The OSLD has been successfully used for the in in-vivo dosimetry of patients who received IMRT	52/2020
9	Correlation between TL and OSL of α -Al ₂ O ₃ :C,Mg	The TL and OSL results were analysed in complementary ways.	The area under the curve, whole range and partial integration, and peak intensity	A correlation between the continuous decay of the main TL peak intensity and OSL signal obtained	53/2018

1.7. CHOICE OF THE TOPIC WITH REASONING

The potential risks associated with radiation exposure in humans are twofold. The primary concern involves the absorbed dose to the skin, which can lead to deterministic effects such as erythema, severe cases of epilation, and necrosis (6-9). The secondary concern revolves around the risk of stochastic effects, particularly the potential induction of cancer. The magnitude of this risk is contingent upon the radiation dose absorbed by radio sensitive organs and tissues within the body. However, accurately measuring these doses poses a considerable challenge.

Beyond the intricacies of skin dose measurements (45-47), both Thermoluminescent Dosimeters (TLD) and Optically Stimulated Luminescent Dosimeters (OSLD) are employed to determine outputs for photon and electron beams within the current spectrum of clinically practiced radiotherapy energy ranges (29-31). The impact of the incident angle of radiation beams on TLD and OSLD has been more extensively studied through simulation models (26-28).

The application of in-vivo dosimetry emerges as a viable solution for measuring surface doses (10, 11, 16-18, 35), providing essential data for reaction management. The present study aims to evaluate and compare the effectiveness of OSL and TL dosimeters in this context.

In conventional breast treatment, a standard approach involves two parallel-opposed tangential fields, followed by a supraclavicular field (Figure 1.8) (44, 45). This strategy ensures sufficient coverage of breast tissue while minimizing radiation exposure to adjacent normal structures such as the lungs, heart, and liver. The introduction of oblique incident beam angles is anticipated to contribute higher surface doses due to the displacement of the charged particle equilibrium region toward the surface (8), along with an increase in electron contaminations and higher photon interactions (8).

Thermoluminescent Dosimeters (TLD) and Optically Stimulated Luminescence Dosimeters (OSLD) are the preferred tools for this purpose. However, recent studies comparing TLD and OSLD in surface dose measurements during MRM are lacking. Additionally, the impact of angular dose effects on measurements during breast irradiation has not been explored in existing research.

By considering the above mentioned problem, the main two objectives of this current study as follows:

1. To assess and compare the accuracy of the angular response of Optically Stimulated Luminescence Dosimeters (OSLD) and Thermoluminescent Dosimeters (TLD).
2. To evaluate the effectiveness of TLD and OSLD in measuring surface doses in vivo during post-Modified Radical Mastectomy (MRM) breast irradiation.

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CHAPTER 2

THERMOLUMINESCENT DOSIMETERS

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CHAPTER 2

THERMO LUMINESCENT DOSIMETERS

2.1. GENERAL INTRODUCTION

Luminescence dosimetry is the application of phosphor materials to gauge the absorbed dose of ionizing radiation by detecting visible photons emitted as a result of the absorbed energy (1). This can encompass techniques such as thermoluminescence (TL), optically stimulated luminescence (OSL), radio photo luminescence, and scintillation. These dosimeters have found widespread use due to their compact size, accuracy, ready availability, re usability, and various other advantageous dosimetric features (1).

When exposed to ionizing radiation, the detector material undergoes ionization, causing some electrons movement to the conduction band while leaving holes in the valence band. These electrons and holes can move within their respective energy bands until they recombine or get trapped by defects. In the absence of external stimuli like heating or illumination, these trapped charges can remain immobilized for varying durations, depending mainly on the depth of the trapping sites. Heating (thermoluminescence or TL) can release these trapped charges. When a trapped electron is released, it can recombine with a trapped hole, leading to the creation of an excited-state defect. The relaxation of these defects through light emission is what causes TL (1-2).

Thermoluminescence Dosimetry (TLD) has witnessed significant development, owing in large part to the commercial availability of reliable radiation detector materials and the introduction of automatic readout systems during the last decades. This evolution has expanded the applicability of TLD across diverse fields, including radiation protection, radiotherapy, brachytherapy, diagnostic radiology, and quality assurance initiatives such as calibration of treatment units and radioactive sources (1-2).

A wide array of TL materials, ranging from powders to micro rods and pellets, offer flexibility in adapting dosimetry to various applications. For instance, in vivo dosimetry, TL dosimeters prove competitive with other detection methods and offer distinct advantages such as high sensitivity within a small volume, tissue equivalence, and freedom from cumbersome connections to Electrometer through cables (3).

Moreover, advancements in equipment selection and methodological approaches have contributed to notable reductions in the time required for readout. This

underscores the importance of investing in suitable equipment and employing efficient methodologies to streamline dosimetry processes (4-5).

2.2. TL PRINCIPLE

Thermoluminescence dosimetry (TLD) operates on the principle of imperfect crystals absorbing and storing the energy of ionizing radiation, which is later re-emitted as electromagnetic radiation, primarily in the visible wavelength, upon heating. The emitted light is then detected and correlated with the absorbed dose received by the TL material. While various theoretical models have been proposed to explain this phenomenon, challenges persist when considering specific dosimetric materials (1-2).

One plausible mechanism for TL involves referencing the band theory of multi-atomic crystalline structures (Fig. 2.1). In this model, energy states within a crystal are depicted with energy increasing upward along the ordinate axis. Upon irradiation, free electrons and holes are generated. These electrons can temporarily move through the solid within the conduction band. Subsequently, they may become trapped at defects, return to the valence band and recombine radiatively or non-radiatively with holes, or be captured at luminescent centers activated by holes due to irradiation, leading to light emission (6).

Under the influence of heating, electrons trapped at metastable energy states acquire sufficient thermal energy to escape from the trap into the conduction band once more. Within the conduction band, they have three potential outcomes: re-trapping at defects, recombining with holes in the valence band radiatively or non-radiatively, or radiatively recombining at a hole-activated luminescent center. The light emitted through this latter process is termed thermoluminescence (TL). Heating and light collection are conducted within a readout system known as a reader (7).

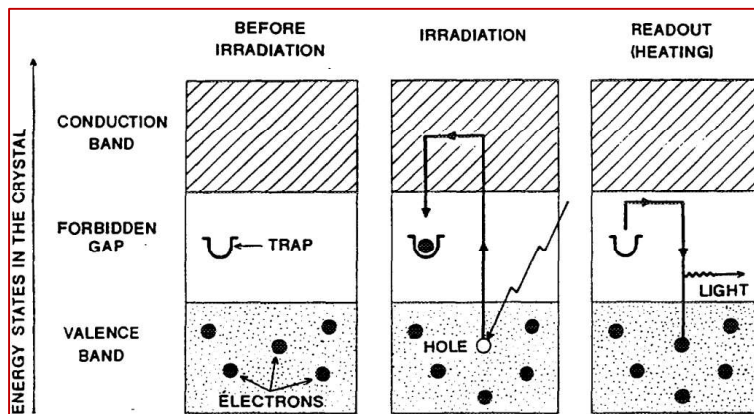


Fig. 2.1. A possible mechanism for thermoluminescence. (G. Marinello, 1996)

A graph depicting TL intensity against temperature is commonly referred to as a “glow curve”. The glow curve consists of multiple TL peaks, with each peak representing a distinct energy state within the crystal lattice. The characteristics of these peaks are influenced by various factors, including the type of TL material (its nature and annealing procedures) and the properties of the irradiation sources. When the temperature of TL material exposed to radiation rises, the likelihood of releasing trapped electrons also increases. Initially, the emitted light (TL) intensifies, reaching a peak value, before gradually diminishing back to zero. This phenomenon occurs because most phosphors contain multiple traps at various energy levels within the forbidden band, resulting in the glow curve comprising several distinct peaks, as illustrated in the Figure 2.2. Each peak corresponds to a specific "trapped" energy level within the material (2-3).

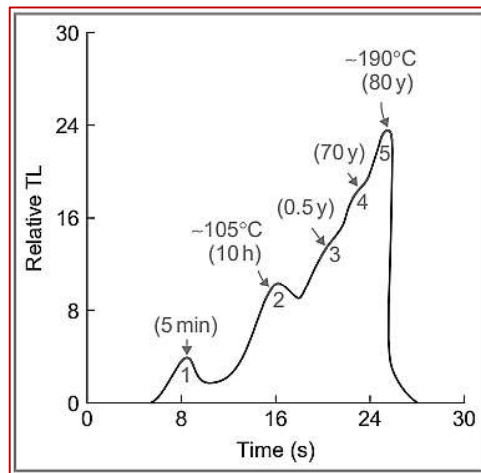


Fig. 2.2. A schematic representation of Glow curve. (G.Marinello, 1996)

2.3. CHOICE OF THE TL MATERIAL

The most commonly utilized TL detectors are derived from doping phosphors like lithium fluoride (LiF), lithium borate ($\text{Li}_2\text{B}_4\text{O}_7$), calcium sulphate (CaSO_4), and calcium fluoride (CaF_2) with activators, such as magnesium and titanium for LiF:Mg-Ti or copper for $\text{Li}_2\text{B}_4\text{O}_7$. These materials are available in both powder and solid dosimeter forms. Solid dosimeters can be fabricated entirely from phosphors, either as single crystals or polycrystalline extrusions (including extruded rods, sintered pellets, or chips), or as homogeneous composites consisting of phosphor powder and binding materials. Notably, the characteristics of pure phosphor dosimeters may significantly differ from those of composite dosimeters (8-9).

For in vivo measurements, TL materials should meet following specific criteria:

- Possess high sensitivity within a small volume
- Exhibit consistent response at both room and patient temperatures
- Demonstrate tissue equivalence to soft tissue, lungs, or bones within the relevant energy range encountered in radiotherapy or radio diagnostics.

The response and chemical stability of TL materials are resilient to climatic variations (8). While the TL signal may fade more rapidly when exposed to intense sunlight, normal room light exposure does not significantly affect the response. Notably, TLDs housed within paper wrappers or polythene pouches are unaffected by sunlight exposure, further ensuring the reliability of dose measurements. The selection of TL material for a particular application can be obtained by theoretical data. However, practical considerations must also be taken into account, including the influence of surrounding materials (e.g., build-up caps and patient tissue) and the size and shape of TL dosimeters, necessitating energy corrections (10).

2.4. TLD READER

The TLD reader employs the integral method of TL measurement, which imposes less stringent requirements on the heating rate. Contact heating is achieved using a kanthal strip, ensuring rapid attainment of the required temperature, which is then maintained to cover the primary TL glow peak (6). Essentially, the reader administers a programmed heating cycle to the TL dosimeter, while simultaneously sensing the instantaneous light emitted by the dosimeter (the glow curve signal), and displaying the total integrated light in terms of mSv (9).

The reader (figure 2.3) features a common display (3½ digit discharge per minute) that provides various indicators, including the instantaneous temperature of the heater (in °C), the EHT (Extra High Tension) supply to the photomultiplier tube (in volts), and the integrated output (EXP) of the sample or calibration (CAL) light source. A timer regulates the duration of the heating/integrating cycle. Background suppression is incorporated to subtract spurious counts (dark current) from the TL reading (6).

On the front panel, a heater raising control knob facilitates the raising of the heater to establish contact with the TL discs. Additional controls include "EHT ADJ" for adjusting the voltage to the photomultiplier tube (PMT) for reader calibration, "STOP" to terminate the reading cycle if necessary, and "RESET" to reset the display to zero (6).

The heater drawer system comprises a gear-controlled metal cassette where the card is loaded. Micro switches and panel lamps indicate the respective TL discs in the reading position. The kanthal strip heater element, positioned below the disc, must be raised at each disc position before initiating the timer/heater cycle. The heater's temperature is monitored by a chromel-alumel thermocouple welded beneath it, with the temperature displayed on the panel. After reading one disc, the card is manually advanced to position the next disc on the heater (6-7).

A newer microprocessor-controlled manual TLD reader has also been introduced, featuring on-line glow curve recording capability and the ability to store dose data and glow curves for numerous dosimeters. Equipped with a liquid crystal display (LCD), this reader can be operated manually or via a PC. It offers various modes, including normal and light source (LS) modes for TL output and light source readings, respectively, along with a test mode for evaluating PMT performance using a light source. Rocker switches on the front panel enable adjustment of cycle time, EHT to PMT voltage, and operating mode (1).

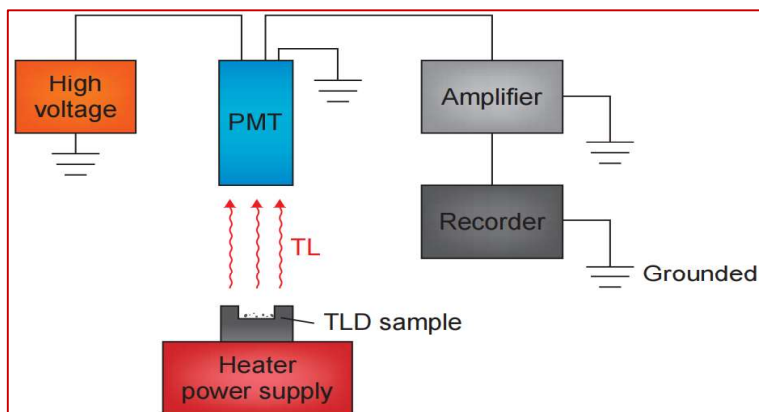


Figure 2.3. Schematic diagram showing apparatus of TLD Reader (F. M. Khan, 2014).

Recently, semi-automatic TLD readers have gained significant popularity, with the TLD badge reader being a prominent example. Capable of automatically processing 50 TLD cards in just 100 minutes, this reader offers several key features. Notably, it can measure doses ranging from a few mSv to 1 Sv without requiring any range switching (1-2). The system comprises microprocessor-based electronic control circuits, a PMT housing, a card transport system for positioning TLD cards for reading, a gas heater and temperature control unit, cooling fans, and a solenoid for regulating gas flow.

The entire reader operation is controlled by a PC. Once the cards are loaded into the magazine and inserted into the reader, with corresponding badge numbers and relevant data manually entered in the same sequence as card loading, the reader automatically reads all 50 cards in the magazine. It generates TL readings for each card in real-time, providing hard copy printouts, and stores the glow curve and TL readings on hard disk for future reference. Advanced self-diagnostic software continuously monitors vital reader circuits, including EHT applied to the PMT, temperature, and gas flow. In the event of a fault detection, the readout process is halted automatically, and a message is displayed on the PC monitor to alert the user, ensuring efficient and reliable operation (1).

2.5. DOSIMETRIC PROPERTIES

2.5.1. SIGNAL STABILITY AFTER IRRADIATION

A crucial factor to consider when selecting a TL dosimeter is the stability of its signal. It's essential to determine whether the charges trapped during irradiation remain intact until readout, without being lost due to unintended exposure to heat (thermal fading), light (optical fading), or any other factor (anomalous fading). This degradation of the TL dosimeter response over time, depending on the duration between irradiation and readout, is a critical consideration (6-8).

A suitable preheating process helps eliminate the signal portion (low temperature peaks) that is susceptible to significant thermal fading, thereby significantly reducing thermal fading for most TL materials. In practical terms, thermal fading should be assessed individually for each TL material intended for use on a specific reader. Ideally, thermal fading should be around 1% per month or less for various preparations of LiF when correct readout and annealing conditions are maintained. This evaluation ensures the reliability and accuracy of TL dosimetry measurements over time (1, 6-8).

2.5.2. INTRINSIC PRECISION

Intrinsic precision refers to the reproducibility of a specific TL material within a designated readout system. This precision is highly reliant on various factors, including the quality of the TL material, characteristics of the reader, definition of preheating and heating cycles, purity of the nitrogen gas used in the readout chamber, among others (1, 6-8).

Assessment of intrinsic precision typically involves randomly selecting 10 samples of TL powder or dosimeters from the same batch and irradiating them to an

identical dose. Following readout, and if necessary, an annealing procedure, this process is repeated multiple times. Upon optimizing readout parameters, a standard deviation of $\pm 2\%$ or less can routinely be achieved with both manual and automatic readers of good quality when paired with reliable TL materials. This level of precision ensures consistent and reliable measurements in TL dosimetry applications (1, 6).

2.5.3. SENSITIVITY

Verification of sensitivity factors is essential to account for potential material loss that may occur when handling TL dosimeters improperly. It is inevitable that some variations in sensitivity will occur within a batch of TL dosimeters. When TL powders are used, it is imperative to precisely define the quantity of powder and the readout conditions, ensuring that corrections are applied when necessary. It is crucial to establish the response variations with the mass of TL material under the readout conditions employed in practice, as they are influenced by the heating kinetics. In cases where TL materials exhibit a signal proportional to the mass under linear heating kinetics, it is necessary to either apply a linear correction with samples of varying weight or ensure the use of samples with equal weight (6, 7).

2.5.4. RESPONSE VARIATION WITH DOSE

It is recommended to use TL dosimeters within the linear region of their response curve, where their response is directly proportional to the received dose. When TL dosimeters are employed outside of this linear region, it becomes necessary to apply a correction to the signal based on a curve established with the specific TL material and reader being used. This correction curve should be periodically verified to maintain accuracy. Furthermore, TL dosimeters should not be utilized in the sub linear region approaching saturation. It's important to note that both supra-linearity and saturation dose levels can be influenced by factors such as improper heating conditions, prior exposures to irradiation, and thermal treatments. These considerations underscore the importance of careful handling and monitoring to ensure accurate dosimetry readings (1, 6, 13-15).

TL dosimeters exhibit a significant degree of dose-rate independence. Most TLDs remain unaffected by dose-rate variations up to 45 Gy and 103 Gy per pulse of 0.1 ms, respectively. This characteristic eliminates the need for dose-rate corrections in practical in-vivo measurements. Even under extreme conditions, such as high dose-rates generated in scanned electron beams, TL dosimeters do not pose any significant challenges (13-15).

Due to the high temperatures necessary to extract the light signal from TL crystals, the response of TL dosimeters remains unaffected by temperature variations within the range relevant to in-vivo dosimetry, which includes room and patient temperatures. However, it is important to avoid storing the dosimeters near heat sources to prevent any potential alterations in their properties (13-15).

2.5.5. INFLUENCE OF ENERGY

With the exception of superficial measurements, TL dosimeters should be enveloped by an appropriate build-up cap that matches the energy and geometric irradiation conditions. This ensures electronic equilibrium, which is crucial for accurate dosimetry readings. When the build-up cap is constructed from tissue-equivalent material, it becomes theoretically feasible to assess the absorbed dose in TL dosimeters and the associated build-up cap when irradiated with high energy photon beams. This evaluation relies on understanding the relative variation of the mass energy absorption coefficient between the TL material under consideration and water, which is dependent on the photon energy (11-12).

For photon energies below 300 keV, it's recommended to use very thin TL dosimeters without a build-up cap. Additionally, it's preferable to utilize lithium borate instead of LiF, and rely on theoretical data depicting the response versus energy each time small-sized TL dosimeters are employed (11-12).

However, for extremely low photon energies (below approximately 50 keV), direct utilization of theoretical curves or any other theoretical data is not advisable. This is because of the shape and dimensions of the detector can lead to significant variations in response within the dosimeter volume. Furthermore, differences in response due to the nature of the activator may also be too substantial in this energy range (11-12).

In such cases, the most suitable approach is to directly compare the response of the TL dosimeters to that of a calibrated ionization chamber. This ensures accurate measurements and accounts for potential discrepancies arising from the characteristics of the TL dosimeter and the radiation field (11-12).

2.6. ANNEALING OF TLD CARDS

2.6.1. OVEN CALIBRATION AND USAGE RESTRICTIONS

The accuracy of the oven's temperature should be verified monthly using reference thermocouple system or thermometer. The oven temperature must not deviate by more than $\pm 2^{\circ}\text{C}$ after reaching the set temperature. This information should be documented along with the date. Ovens designated for annealing TLD cards should not

be utilized for any other purpose. Each oven should not anneal more than 500 TLD cards at a time (13-15).

2.6.2. PREPARATION OF CARDS FOR ANNEALING

Upon receipt from the supplier, TLD cards should be cleaned with acetone. Prior to each annealing process during field use, the cards should be inspected for cleanliness and appropriately cleaned if necessary. Trays used for annealing should also be cleaned with acetone before usage and stored in a clean, dust-free environment. After acetone cleaning, the cards should be air-dried at room temperature for 12–16 hours (13-15).

2.6.3. TEMPERATURE AND DURATION OF ANNEALING

The trays containing TLD cards should be placed in the oven, and the temperature should be raised from ambient to 230°C. This temperature should be maintained for 4 hours. The oven temperature should be allowed to decrease, and the trays with TLD cards should be removed only when the temperature drops below 80°C (13-15).

2.6.4. VERIFICATION OF PROPER ANNEALING

A minimum of 5 TLD cards from each tray should be selected and read on a calibrated reader. The TL readout of these cards should fall within acceptable limits. Records of these readouts should be maintained in a separate logbook (14-15).

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CHAPTER 3

OPTICALLY STIMULATED LUMINESCENT DOSIMETERS

- 3.1. GENERAL INTRODUCTION
- 3.2. OSL PROCESSES
- 3.3. TYPES OF OSLD
- 3.4. OSLD PRODUCTION
 - 3.4.1. DOPPING TECHNOLOGY
 - 3.4.1.1. SOLID-STATE REACTION METHOD
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- 3.5. APPLICATIONS
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CHAPTER 3

OPTICALLY STIMULATED LUMINESCENT DOSIMETERS

3.1. GENERAL INTRODUCTION

Optically stimulated luminescence (OSL), also referred to as photo-stimulated luminescence or photo stimulable luminescence (PSL), describes the phenomenon where emission occurs when a material, previously exposed to light radiations (e.g., X-ray and UV light) and ionizing radiation (such as photons, electrons, and protons), is subjected to suitable optical stimulation (1,2). In a perfectly crystalline insulator, the conduction and valence bands are separated by an energy difference, and there are no intermediate energy levels within this band gap. Luminescence detectors are created by introducing impurities into these crystals, which introduces energy levels within the band gap near the impurities. When exposed to ionizing radiation, the material absorbs energy, leading to ionization of electrons that are promoted to the conduction band, leaving holes in the valence band. These free charge carriers can move until they recombine or captured by defects in the lattice structure, forming "electron traps" and "hole traps", as in the figure 3.1 (1,2). Without additional stimuli like heating or illumination, these excited charge carriers remain localized in traps, primarily depending on the depth of the trap relative to the conduction or valence band (1,2).

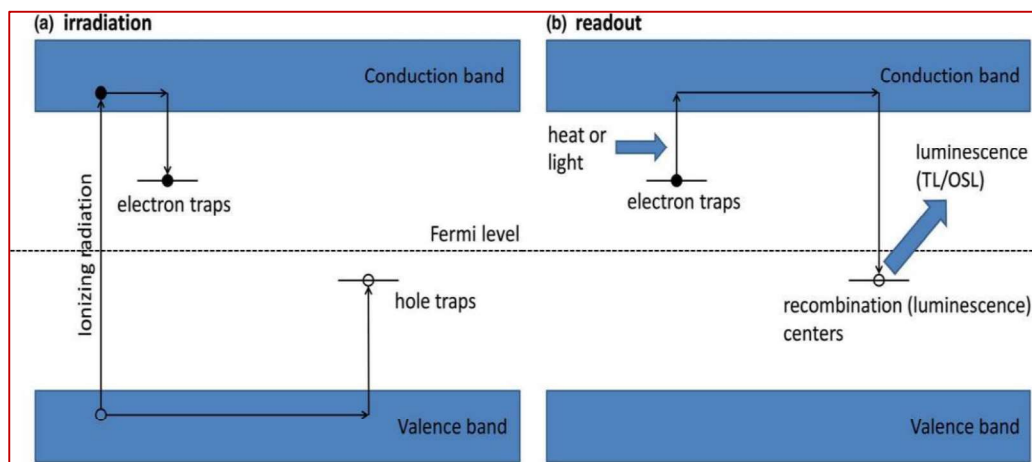


Figure 3.1. Schematic energy level diagram representing the valance, conduction bands and electronic transition during irradiation (a) and during readout procedure (b). (Kry et al. American Association of Physics in Medicine Task Group Report 191)

After removing the irradiation source, the captured charge carriers can be liberated from the traps to the conduction band due to the absorption of energy under external light illumination. Recombination of electrons and holes or transitions of electrons to emitting centers lead to the generation of OSL (1-3). These processes can cause phenomena like dose response supra linearity and sensitivity changes with the detector's dose and annealing history. TL/OSL readers stimulate the detector using heat or light and monitor luminescence using a photomultiplier tube (PMT).

3.2. OSL PROCESSES

OSL dosimeters can be read using light of constant or variable intensity. The OSL signal decreases exponentially as trapping centers empty (3). Multiple trapping center types affect fading, reuse, and readout (Figure 3.2). Factors like stimulation light type, intensity, and duration influence the OSL decay curve. The OSL reader typically consists of a light source, optical filters, and a PMT. OSL materials offer advantages over TSL in various applications due to their all-optical features, stable sensitivity, high luminescence efficiency, and controllable readout speed. Dosimetric properties depend on various factors, including the dosimeter, reader, and calibration procedures (3,4). OSL materials find applications in various fields due to their controllable energy absorption, storage, and release properties (5-7).

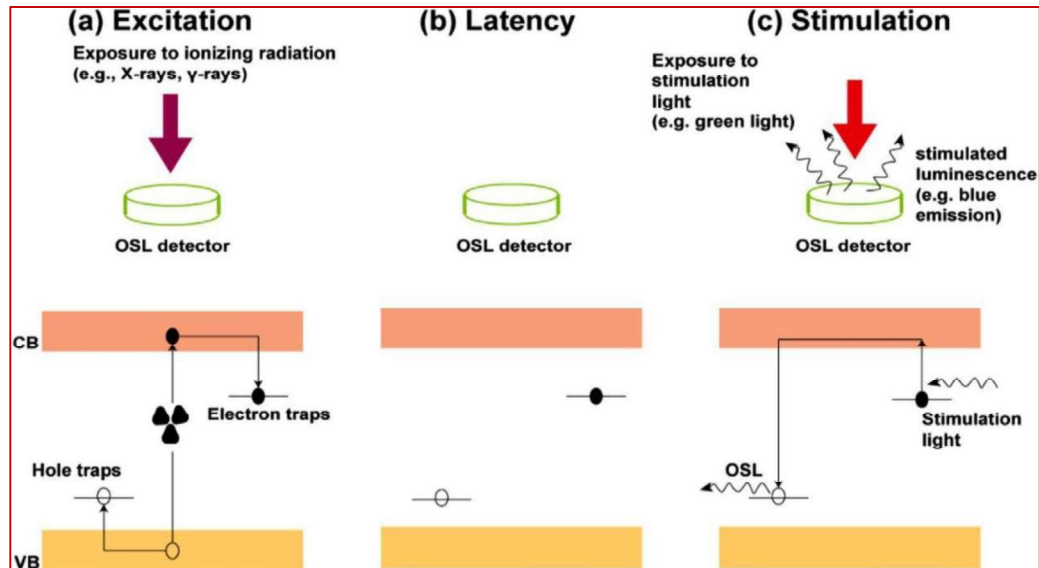


Figure 3. 2. Three different stages involved in the OSL processes: a) Excitation of the OSL detector by ionizing radiation creating free electrons (●) and holes (○); b) The state of latency with meta-stable electrons and holes captured by traps in the host; and c) Stimulation

of the detector with light, leading to the release of charge carriers along with light emission (OSL). The upper panel illustrates the interaction of the detector with the ionizing radiation and stimulation light; the lower panel represents the energy band diagram with the available energy levels and corresponding electronic transitions occurring at each stage. (Kry et al. American Association of Physics in Medicine Task Group Report 191)

Optically stimulated luminescent dosimeters (OSLDs) can be assessed using light, which can have either a consistent intensity (continuous-wave method) or a varying intensity (pulsed method) (1-3). The emission of OSL decreases exponentially as the trapping centers are vacated, as depicted in the continuous-wave readout illustration 3.3.

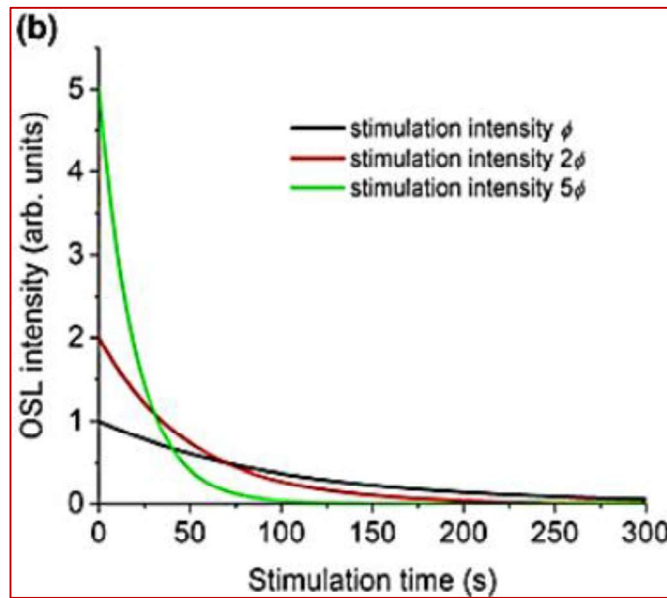


Figure 3.3. OSL curve of typical phosphor containing one type of recombination center (Kry et al. American Association of Physics in Medicine Task Group Report 191)

However, the OSL curve for practical materials is not a simple exponential due to the presence of multiple trapping centers. Generally, these traps can be categorized into three types: shallow-depth traps that are unstable at room temperature, medium-depth traps that can be released with light exposure in the visible spectrum, and deep-depth traps that are challenging, if not impossible, to empty once filled. The dynamics and interaction among these various trap types influence factors like fading, reusability, and the reading process of OSLDs (5, 6).

Moreover, the OSL decay curve is influenced by factors such as the type (broadband vs. monochromatic), intensity, and duration of the stimulation light. Higher stimulation intensity initially boosts the OSL signal, but it also accelerates signal decay.

Typically, commercial readers stimulate the detector for about one second, allowing only a portion of the trapped charge to be released. During this stimulation period, the total signal is recorded for continuous-wave illumination. Alternatively, in the pulsed technique, the stimulation consists of short light pulses, and the readout is conducted during intervals when the stimulation source is inactive. While this method enhances the signal-to-noise ratio, it doesn't significantly alter the practical utility or precision of the system (5-7).

The fundamental components of an OSL reader are depicted in the Figure 3.4, although a set-up with the light source and detector in a transmission orientation may also be employed. Stimulation is typically achieved using a light source like a laser, light-emitting diode (LED), or broadband lamp, with optical filters commonly employed in front of the light source to select specific stimulation wavelengths (1,5-7).

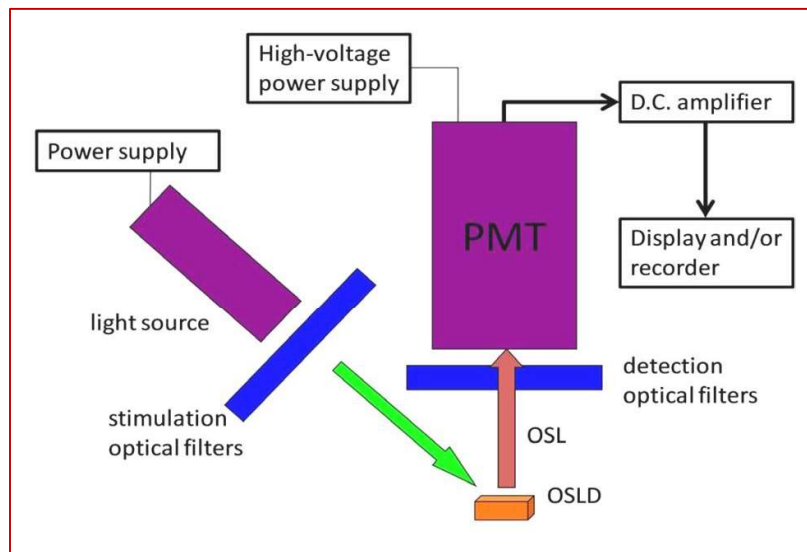


Figure 3.4. OSLD Reader schematic representation (Kry et al. American Association of Physics in Medicine Task Group Report 191)

A transmission orientation of the light source and detector can also be employed. Light stimulation is typically achieved using a laser, LED, or broad-band lamp. Optical filters are commonly placed in front of the light source to select specific stimulation wavelengths and to block wavelengths that overlap with the OSL signal (8).

Similarly, optical filters are utilized in front of the photomultiplier tube (PMT) to prevent the stimulation light from reaching it while allowing transmission of the OSL signal. For instance, in the case of an Al_2O_3 : C dosimeter, green light from a laser or

LED (~525 nm) is typically used for stimulation, with the emission band falling within the blue spectrum (~420 nm) (8,9).

The dosimetric characteristics of a specific OSL system rely on the entire dosimetry set-up, which encompasses the dosimeter itself, preparation procedures, dosimeter holder, reader, choice of signal, temperature, dose rate, and maximum dose applied, photomultiplier tube, and the algorithm utilized for estimating the desired quantity (1, 9, and 10). Consistency in their use are crucial as these factors can influence the outcomes significantly. To mitigate variations in system response, it's vital to establish a stable, reproducible process for illuminating the OSLD and ensure consistent light sensitivity of the PMT. This can be achieved through session-specific calibration of the detector and implementing suitable quality assurance protocols for the reader (9, 10).

In principle, the intensity of OSL is directly proportional to the absorbed radiation dose and the stimulation light. OSL materials, with their energy conservation properties allowing controllable absorption, storage, and release of energy, find widespread applications across various fields including environmental science, biomedical science, security encryption, food safety, radiation dosimetry, luminescence dating, advanced photonics, and optical data storage (ODS) (9).

3.3. TYPES OF OSLD

Numerous materials possess luminescent properties that render them broadly applicable as radiation dosimeters. Indeed, the distinction between Optically Stimulated Luminescent Dosimeters (OSLDs) and Thermoluminescent Dosimeters (TLDs) is somewhat arbitrary because most materials can exhibit both Thermoluminescence (TL) and OSL signals. For instance, $\text{Al}_2\text{O}_3\text{:C}$ has been utilized as both TLD and OSLD. However, typically, materials tend to exhibit superior properties when used with either thermal or optical stimulation (10-12).

In both TLD and OSLD, various types of luminescent dosimeters (LDs) exhibit distinct properties. For general dosimetry in radiotherapy environments, LiF:Ti , Mg (TLD-100), and $\text{Al}_2\text{O}_3\text{:C}$ (nanoDot) are well-suited due to their characteristics (10-12). The evaluation of detector performance discussed in this report is primarily based on these two dosimeters. Other LDs may possess properties that make them particularly suitable or unsuitable for specific applications. For example, TLD-100H offers high sensitivity and is ideal for low-dose (1 μGy -10 Gy) applications. TLD-600 (neutron-sensitive) and TLD-700 (neutron-insensitive) can be paired to measure thermal neutron

doses. Calcium-based thermo luminescent dosimeters are highly sensitive for very low-dose applications in the mGy range but are relatively uncommon in routine medical use due to their significant energy dependence (12).

The dosimetric characteristics of a TL/OSL detector are influenced by the defects involved in the TL/OSL process and are not solely dependent on the host material (1). The density, distribution, and energy-depth of defects directly impact features such as sensitivity. This discrepancy is evident when comparing TLD-100 and TLD-100H, both based on LiF, yet exhibiting dramatic differences in sensitivity due to different dopants and trap structures. Moreover, because ionization densities generated by various types or energies of ionizing radiation interact with defects differently, the nature of defects can also affect the energy response and linearity of the detector (1, 13, 14).

3.4. OSLD PRODUCTION

Luminescent dosimeters (LDs) produced in a specific manufacturing batch exhibit similar properties concerning fading, linearity, and energy dependence. However, the average sensitivity can vary significantly between different productions runs, potentially by more than 20% (12-13).

Optically Stimulated Luminescent Dosimeters (OSLDs) are currently available commercially only in the form of disks or strips. For medical applications, there's presently only one commercial material: $\text{Al}_2\text{O}_3\text{:C}$. This crystal is ground into a relatively uniform powder and affixed onto a plastic tape, which is then punched into disks and mounted into light-tight plastic cassettes. Originally distributed as the microdot, the current iteration is the smaller nanoDot, with a readable area comprising a disk 4 mm in diameter and 0.2 mm thick (1, 12-14).

3.4.1. DOPING TECHNOLOGY

3.4.1.1. SOLID-STATE REACTION METHOD

The conventional solid-state reaction method involves heating mixtures of solids to form a solid phase product through diffusion between them. This process undergoes four reaction stages: diffusion, reaction, nucleation, and growth. The reaction process entails significant bond breaking and subsequent reorganization into a new crystal structure. While this method offers advantages such as simplicity, availability, low cost, large-scale production, and the ability to introduce defects essential for OSL performance, it requires high temperatures and long reaction times.

Drawbacks include unwanted aggregation, large grain size of particles, and difficulty in controlling morphology homogeneity (1, 12-14).

3.4.1.2. SOL-GEL METHOD

To address the limitations of solid-state reactions, soft chemical synthesis methods like the sol-gel methods are employed. This method, divided into aqueous and non-aqueous routes, is commonly used for synthesizing nano particles. It offers advantages over the solid-state reaction method due to the high degree of homogeneity achieved through molecular-level mixing of starting materials (1). The aqueous sol-gel method is particularly popular and provides better control over the micro morphology surface of the nano materials. The process involves hydrolysis, condensation, and drying steps, resulting in products with controlled morphology. Various nano particles exhibiting OSL, like $\text{LiGa}_5\text{O}_8:\text{Cr}^{3+}$ and $\text{ZnGa}_2\text{O}_4:\text{Cr}^{3+}$, have been synthesized using this method (12-14).

3.4.1.3. COMBUSTION SYNTHESIS

Combustion synthesis is characterized by effectiveness, fast heating rate, low cost, and short reaction time, making it suitable for producing industrial materials, especially small-sized particle materials. The reaction involves the intense self-sustained exothermic process of organic fuel and metal salts in an aqueous solution. It offers advantages such as lower equipment requirements, simplicity, high-purity product with small size and uniformity, high thermal gradients, and rapid cooling rates (10-13).

3.4.1.4. HYDROTHERMAL AND SOLVOTHERMAL TECHNIQUES

Hydrothermal and solvothermal syntheses are mild synthetic techniques used for preparing inorganic materials at low temperatures. These methods involve chemical reactions in aqueous or non-aqueous solutions, respectively, above the boiling point of water. They enable controllable morphology, crystal size, and operability through liquid nucleation, attracting attention for the synthesis of high-tech nano materials and biomolecules (10, 12).

3.4.1.5. CO PRECIPITATION METHOD

Co precipitation is a convenient method for preparing materials with small size and narrow distribution. It offers advantages such as operation under mild conditions, simplicity, and the ability to prepare nano particles directly without post-calcination. The process involves nucleation, growth, coarsening, and agglomeration, and through

adjustments in factors like temperature, pH, precipitating agent, additives, and solvents, desired particles can be obtained (11, 12).

3.5. APPLICATIONS

The utilization of Optically Stimulated Luminescence (OSL) in medical dosimetry is in its early stages but is steadily expanding. Two primary properties of OSL are particularly leveraged in medical dosimetry applications: high sensitivity and the all-optical nature of the process. The high sensitivity allows for the creation of small dosimeters, granting them high spatial resolution. Consequently, they have the potential to measure doses in regions with significant dose gradients. The all-optical nature of the process also enables its use with optical fibers, facilitating dose measurements in hard-to-reach locations, potentially even inside the human body. Moreover, the combination of these properties permits OSLDs to record doses in near real-time during exposure, enhancing the capabilities of dosimetry systems (9-12).

Advancements in radiation medicine, including radio diagnosis, radiotherapy, and interventional radiography, introduce new dosimetry challenges for medical physicists. For instance, the shift towards using charged particles like protons and carbon ions in radiotherapy presents novel tests for dosimetrists compared to traditional high-energy photons. Additionally, sophisticated intensity modulation techniques with photons create new complexities beyond the basic objective of dose measurement. In all these areas, a delicate balance must be struck between effectively treating the tumor and minimizing exposure to healthy tissue. Innovative applications of OSL dosimetry are emerging in each of these domains to assist medical physicists and oncologists in designing the most efficient and least harmful treatments for their patients (1, 9-12).

In radio diagnosis, OSL has been successfully employed in imaging systems, where it is also known as photo-stimulated luminescence (PSL). The sensitivity and rapid readout of the stimulated luminescence signal enable radiologists to reduce radiation doses to patients while providing high-resolution images for diagnostic purposes. However, it's important to note that the use of OSL in imaging systems doesn't constitute dosimetry itself. The actual dose to the patient is still determined using conventional OSL (or TL) methods (9, 12-14).

3.6. RADIATION DOSIMETRY

The intensity of Optically Stimulated Luminescence (OSL) serves as a direct indicator of the radiation dose absorbed by the dosimeter, forming the basis of a

radiation dosimetry technique. The high sensitivity and all-optical features of OSL materials make them particularly valuable in radiation dosimetry applications (1). These applications span a wide range, from environmental monitoring and UV dosimetry for personal protection to food security, sensor technology, detection systems, on-board dosimetry in space, and counter-terrorism efforts, including the detection of nuclear or radiological weapons (1).

In the context of modern radiotherapy, which includes complex techniques such as intensity-modulated radiation therapy (IMRT) and stereo tactic radio surgery, dosimetric systems face significant challenges in delivering accurate dose evaluations. The inherent high sensitivity of OSL materials suggests their efficacy at low dosages with exceptional spatial resolution and accuracy. Moreover, their all-optical nature allows for real-time monitoring using optical fibers, facilitating dose detection in challenging or inaccessible locations, including hazardous environments and even within the human body (9, 12-14).

In radiation medicine, particularly in fields like radio diagnosis, radiotherapy, and interventional radiography, delivering the appropriate radiation dose to destroy tumors while minimizing exposure to healthy tissue is paramount. Innovations in OSL dosimetry have been developed to support medical physicists and oncologists in designing the safest and most effective treatments for patients (1).

3.7. REFERENCES

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CHAPTER 4

MATERIALS AND METHOD

- 4.1. EQUIPMENT AND INSTRUMENTATION USED IN THIS STUDY
- 4.2. LINEAR ACCELERATOR (LINAC)
- 4.3. TREATMENT PLANNING SYSTEM (TPS)
- 4.4. RADIATION FIELD ANALYSER SYSTEM (RFA, PTW GERMANY)
- 4.5. IONIZATION CHAMBERS (PTW, GERMANY)
- 4.6. ELECTROMETER (PTW, GERMANY)
- 4.7. THERMO LUMINESCENT DOSIMETER (THERMO FISCHER SCIENTIFIC, MODEL 3500)
- 4.8. OPTICALLY STIMULATED LUMINESCENT DOSIMETERS (NANO DOTS, LANDAUER MICROSTAR)
- 4.9. CALIBRATION PROCEDURE
- 4.10. METHODOLOGY
- 4.11. REFERENCES

CHAPTER 4

MATERIALS AND METHOD

4.1. EQUIPMENT AND INSTRUMENTATION USED IN THIS STUDY

The equipment and measuring instruments used in this cross-sectional study are outlined as

Linear Accelerator (LINAC) - ELEKTA versa HD (Elekta M/S, Sweden)

Treatment Planning system (TPS)- Eclipse- V16.00 (Varian M/S, US).

Radiation Field Analyser system (RFA, PTW Germany)

Ionization Chambers (PTW, Germany)

Electrometer (PTW, Germany)

Thermo luminescent dosimeter (TLD) (TLD reader- Thermo Fischer Scientific, Model 3500)

Optically stimulated luminescent dosimeters (OSLD), OSLD Reader (Nano Dots, LANDAUER microSTAR)

4.2. LINEAR ACCELERATOR (LINAC)



Figure 4.1. Elekta Versa HD Linear Accelerator

Elekta medical system introduced an advanced medical linear accelerator named Versa HD (Figure 4.1) with features like delivers up to 6x more modulations per arc, fast leaf speeds up to 6.5 cm/s, jaws leaf speed of 9 cm/s and High Dose Rate allowing any

SRS/SBRT treatment in a standard treatment time that too including 4D image-guided radiotherapy. Agility high-resolution MLC to deliver treatments with 1 mm virtual leaves and a full 40 cm x 40 cm field size (1).

4.3. TREATMENT PLANNING SYSTEM (TPS)

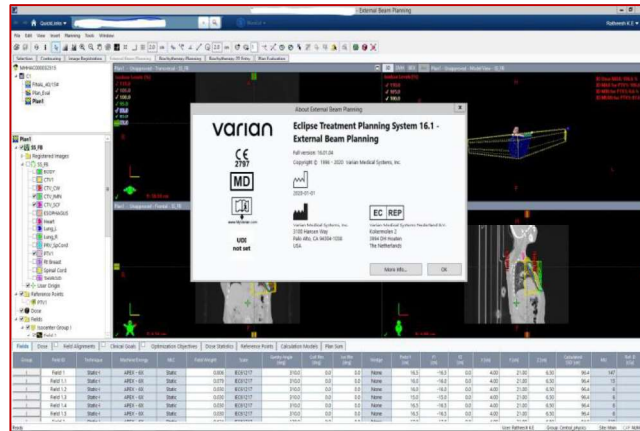


Figure 4.2. Varian Eclipse TPS Application Page

Treatment planning system (Figure 4.2) involved in this research belongs to Varian medical systems (now known as Varian – A Siemens Healthineers Company) named Eclipse-version 16.00. This system boasts a versatile range of capabilities, including image registration (both rigid and deformable), multi-image fusion, contouring, and treatment planning. It supports various treatment modalities such as 3DCRT, IMRT, VMAT, SRS/SBRT, each with distinct dose optimization and calculation algorithms. In this research, the calculations were executed using the AAA algorithm (1).

4.4. RADIATION FIELD ANALYSER SYSTEM (RFA, PTW GERMANY)



Figure 4.3. PTW MP3 RFA system

The MP3-M RFA system (Figure 4.3) serves as a comprehensive LINAC QA solution, offering seamless reference dose measurements in vertical, horizontal, and arbitrary planes in accordance with national or international standards like the AAPM TG 142. Equipped with a versatile range of features, the MP3-M accommodates various Gold standard application-specific detectors and is suitable for field sizes up to 40 cm x 40 cm. The system includes a removable control pendant with a TFT display and a menu-controlled interface for convenient manual control and set-up. The height adjustment of the MP3-M water reservoir, facilitated by the SCANLIFT lifting carriage, enhances ease of use. It incorporates a built-in powerful pump for rapid filling and draining by gravity. The MP3-M features the patented TRUFIX system for swift axial and radial detector set-up, optimizing efficiency. Integrated with MEPHYSTO mc² software, it facilitates seamless TPS beam data acquisition and analysis. Additionally, its customizable multiple-queue drag-and-drop task lists enhance work flow management (2).

4.5. IONIZATION CHAMBERS (PTW, GERMANY)

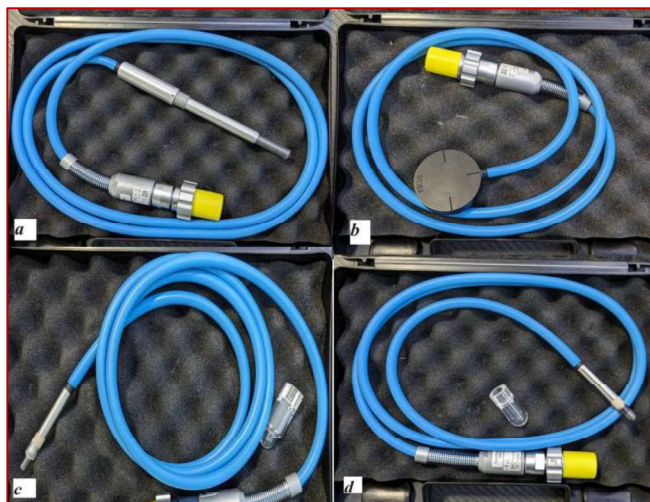


Figure 4.4. Ionization Chambers: a) Farmer type 0.6 cc volume chamber, b) parallel plate (0.35 cc), c) Pin point chamber (0.03 cc), and d) Semi flex 0.125 cc

The Farmer chambers represent a prevalent choice for reference dose measurements in radiotherapy shown different chambers in the figure 4.4, featuring a vented sensitive volume of 0.6 cc enclosed by a graphite acrylic wall and an aluminum central electrode. The water proof design allows the chamber to be used in water or

solid state phantoms. The chamber's characteristics adhere to standards set forth by IEC 60731 and AAPM TG51 Addendum (6).

In addition to the Farmer chambers, this study also incorporates semi flex ionization chambers, boasting a vented sensitive volume of 0.125 cc and optimized for high-precision reference dose measurements. These chambers are meticulously characterized to minimize directional response, achieved through their approximate spherical design, ensuring effective integration into the RFA system. Their waterproof and semi-flexible design facilitates straightforward mounting within the RFA system, enhancing usability and versatility (2-3).

4.6. ELECTROMETER (PTW, GERMANY)



Figure 4.5. Electrometer (PTW, Germany)

The PTW UNIDOS ROME0 (Figure 4.5) is a versatile reference class Electrometer suitable for field use in radiotherapy settings. It provides readings of both dose or charge (nC) and dose rate or current (nA) measured by an ionization chamber. It is designed for stand-alone use primarily with intuitive touch screen interface. Notably, the device features an adjustable high voltage range spanning from 0 to ± 400 V, with adjustments possible at 50 V intervals. The Electrometer comes with built in detector database for ready to use detector templates (2-3).

4.7. THERMO LUMINESCENT DOSIMETER (ThermoFischer Scientific, Model 3500)

Thermoluminescence, characterized by thermally activated phosphorescence, stands out as a remarkable and widely recognized phenomenon among various thermally activated effects induced by ionizing radiation. Its practical applications span from dating archaeological pottery to radiation dosimetry.



Figure 4.6. TLD and TLD Reader

TLDs (Figure 4.6) are available in diverse forms, including powder, chips, rods, and ribbons. Before their use, TLDs require annealing to eliminate residual signals. It is crucial to employ well-established and reproducible annealing cycles. Furthermore, TLDs necessitate calibration before usage, as they function as relative dosimeters. To derive absorbed doses from thermoluminescence readings, several correction factors need to be applied, including those for energy, fading, and dose response non-linearity.

Typical applications of TLDs in radiotherapy encompass *in vivo* dosimetry on patients, either as part of routine quality assurance protocols or for dose monitoring in specialized cases, such as complex geometries, doses to critical organs, total body irradiation (TBI), and brachytherapy. Additionally, TLDs are utilized in verifying treatment techniques using various phantoms, including anthropomorphic phantoms. They also play a crucial role in dosimetry audits, such as the IAEA–World Health Organization (WHO) TLD postal dose audit program (5-6).

4.8. OPTICALLY STIMULATED LUMINESCENT DOSIMETERS (NANO DOTS, LANDAUER MICROSTAR)

Optically Stimulated Luminescence (OSL), operates on a principle similar to thermoluminescence dosimetry but with a notable difference: instead of heat, it utilizes light, typically from a laser, to release trapped energy in the form of luminescence. This innovative technique holds promise for *in-vivo* dosimetry applications within radiotherapy. The optically stimulated thermoluminescent dosimeter comprises a small chip (approximately 1 mm³) of carbon-doped aluminum oxide (Al₂O₃: C).



Figure 4.7. OSLD and OSLD Reader

The OSLD (Figure 4.7) reading process involves exciting the chip with laser light transmitted through an optical fiber. Subsequently, the resulting luminescence, typically blue light, travels back through the same fiber, undergoes a 90° reflection by the beam splitter, and is measured by the PMT. Notably, the OSL dosimeter exhibits high sensitivity across a broad range of dose rates and doses commonly encountered in radiotherapy. The OSL response typically demonstrates linearity and independence concerning energy and dose rate, albeit angular response necessitates correction.

Various experimental configurations exist, such as pulsed OSL or the coupling of OSL with radio luminescence. Radio luminescence emits promptly during dosimeter irradiation, providing insight into the dose rate at that moment, while OSL furnishes information regarding the integrated dose thereafter.

Typically, OSLDs can be used in the place of TLD thus replacing laborious reading and annealing procedures associated with TLDs. Compared to TLDs, OSLDs boast several advantages, including faster readout times and simplified post-irradiation procedures. Rather than necessitating the time-consuming annealing process required by TLDs to erase residual signals, OSLDs can be promptly read after irradiation, eliminating the need for extended waiting periods and intricate heating procedures (6).

4.9. CALIBRATION PROCEDURE

Radiation beam profile and machine output of the Linear accelerator (Versa HD, Elekta MS), have been carefully measured and calibrated to ensure minimal variation across the entire irradiation field used in the clinical range. This calibration was confirmed using the Radiation Field Analyser system (RFA, PTW Germany) and 0.6 cc ionization chambers that are traceable to the reference standard laboratory (RSD,

AERB, Mumbai, India). The field profile has been adjusted to achieve a uniform dose distribution throughout the radiation field, with a variation of only 2% (4).

The TLD reader PMT (Photomultiplier tube) operated within a voltage range of 850 V to ensure optimal signal-to-noise ratio. A consistent time-temperature profile, achieved through a heating rate of 10°C/s, was meticulously maintained from a pre-set temperature of 50°C to 300°C for a duration of 4.5 seconds. This facilitated the recording of both the thermoluminescence glow curve and the integrated thermoluminescence light output. Subsequently, annealing of the TLD dots was meticulously conducted at 400°C through a precise annealing process. Sensitivity factor determination, also known as the Element Correction Coefficient, was meticulously carried out for all TLDs with known doses, facilitating the formation of a comprehensive calibration curve spanning from 0.25 Gy to 6 Gy (Figure 4.8)

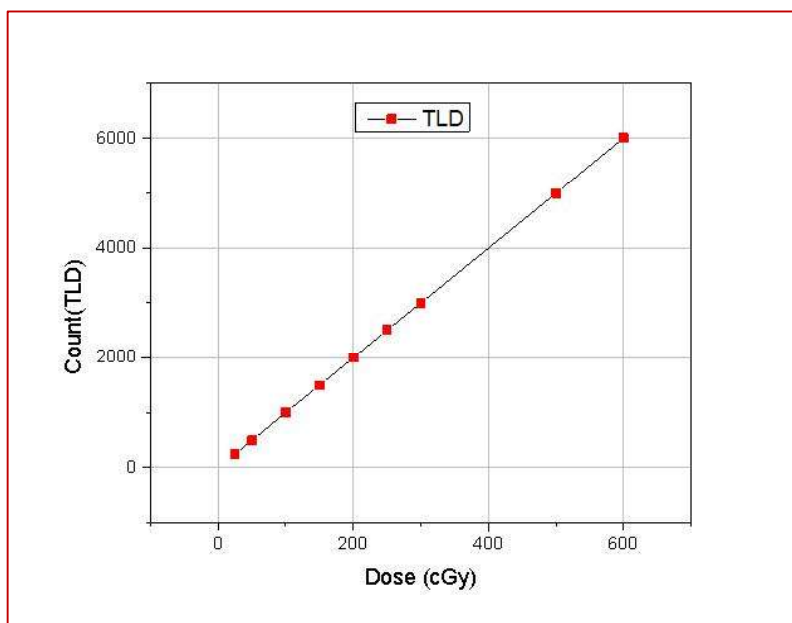


Figure 4.8. TLD Calibration Graph

Similarly, prior to each process, rigorous quality testing of the OSLD reader was conducted, and OSLDs were subjected to bleaching under high-intensity light before exposure. Sensitivity correction was meticulously applied to all OSLD nanoDots, followed by the formation of a calibration curve spanning a dose range analogous to that of the TLDs (Figure 4.9). Given that the experimental set-up operated within the therapeutic range of radiation dose, specifically between 2 Gy and 2.6 Gy, background correction was deliberately omitted in accordance with the guidelines outlined in the AAPM document (7-8).

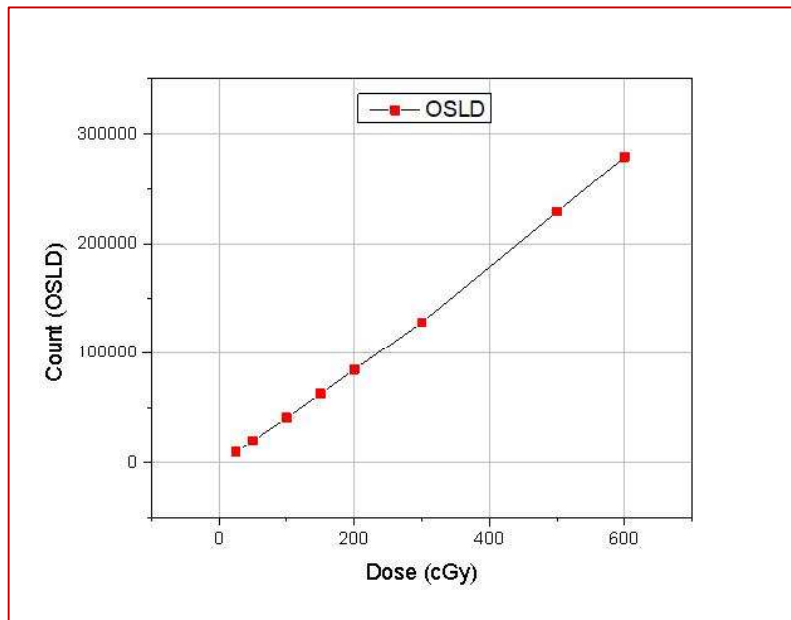


Figure 4.9. OSLD Calibration Graph

The entirety of the procedure was meticulously carried out within a specially designed Linear Accelerator treatment room, adhering to a series of meticulous steps to align and configure the detectors according to the treatment field size. Initially, the room's laser system played a crucial role in defining the treatment isocenter, where subsequent calibration of treatment dose was meticulously performed. Additional alignment refinement was achieved through the strategic use of a diaphragm cross wire, working in tandem with the laser system. To ensure precise determination of the treatment field size, a light field characterized by a defined field size was effectively employed. Furthermore, a cross-marked slab phantom was instrumental in positioning the phantom along the designated field size, aligning it accurately with the laser system. Prior to finalization, detector positions were pre-marked and subjected to meticulous verification using the computed tomography system, ensuring impeccable placement accuracy. Control over gantry and collimator motion was diligently managed by the console, enabling the precise setting and replication of these elements to align with the planned position. To ascertain reproducibility and accuracy, the entire set-up underwent comprehensive simulation utilizing computed tomography. Ultimately, dose estimation was meticulously executed through the treatment planning system (TPS), guaranteeing meticulous dosimetric calculations and planning integrity (5-6).

4.10. Methodology

Female patients undergoing Modified Radical Mastectomy (MRM) breast irradiation were selected for this cross-sectional study, regardless of age, ethnicity, weight, or height. The study included patients with both right- and left-sided breast cancers, ensuring equal representation for thermoluminescent dosimeters (TLD) and optically stimulated luminescent dosimeters (OSLD) measurements. The prescribed dose for the study was 40 Gy, delivered in 15 fractions. The average field size across all patients was 22 cm², with treatment gantry angles ranging from $\pm 48^\circ$ to $\pm 65^\circ$.

Various factors were analysed, including surface dose deviation, off-axis positional dose deviation, the effect of field size, inhomogeneity, and spatial dose dependence. Measurements and statistical analysis were conducted to evaluate these factors. The surface dose measured by the treatment planning system (TPS) was compared and correlated with the results obtained from both OSLD and TLD measurements.

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CHAPTER 5

ANALYSIS OF TLD AND OSLD ANGULAR RESPONSE IN CLINICAL 6 MV BEAM APPLICATIONS

- 5.1. GENERAL INTRODUCTION
- 5.2. EXPERIMENTAL DETAILS
- 5.3. RESULT AND DISCUSSION
- 5.4. CONCLUSION
- 5.5. REFERENCES

CHAPTER 5

ANALYSIS OF TLD AND OSLD ANGULAR RESPONSE IN CLINICAL 6 MV BEAM APPLICATIONS**5.1. GENERAL INTRODUCTION**

Luminescence properties of solid materials, such as optically stimulated luminescence dosimeters (OSLDs), thermoluminescence dosimeters (TLDs), and radiophotoluminescence dosimeters, play a crucial role in clinical practice, particularly in dosimetry. These dosimeters are highly valued for their small size, high spatial resolution, and ability to cover a wide range of dose responses. They are particularly useful for in vivo dosimetry in radiotherapy (1-3).

In luminescent detectors (LD), the amount of radiation is determined by measuring the light signal produced by the interaction of radiation with the dosimeter (4, 5). This is based on the radiative recombination of electrons and holes at luminescent centers within the LD material (6-8). The luminescence efficiency of an LD is affected by various factors, including the number of traps and other defective centers that secondary electrons encounter and how they interact at the luminescent center (9, 10).

The interactions of ionizing radiation change with radiation energy, which in turn varies as radiation passes through a phantom. These variations can affect the efficiency of the LD, and there is no universal method to account for these changes based solely on dosimeter material properties (11, 12). Even slight changes in the concentration of a dopant (at the ppm level) can significantly alter the photon energy response of the same material, which is responsible for its luminescent properties. Additionally, variations in the incident radiation and the amount of backscattering from the medium can influence the efficiency of the LD (10-12).

The AAPM task group report 191 (7) addressed the variation in LD response due to the angle of radiation incidents in two ways: overestimation caused by increased interaction in the medium due to oblique radiation incidents and the angular dependency of the LD material. While the former problem is unavoidable, manufacturers account for it by providing a little extra tolerance level in the LD. The latter problem can be mitigated through accurate dose measurement set-up, evaluating irradiation conditions, and managing the LD before and after irradiation (13, 14).

The present study aims to evaluate the angular response of TLD (LiF: Mg, Ti - TLD-100, Thermo Fisher Scientific) and OSLD (Al₂O₃: C, nanoDot TM, Landauer Inc) in a 6 MV clinical beam, as 6 MV is commonly used in clinical radiotherapy. The study

also compares the response of individual LDs under clinical scenarios. Understanding the effect of angular response in LDs is crucial in radiotherapy, as accurate measurement of the dose in oblique treatment conditions is essential for effective surface dose analysis and improved clinical decision-making and patient care. This study is aimed at evaluating the performance of TLD and OSLD in 6 MV clinical photon interactions with various field sizes and angles, with the goal of achieving less variation in clinical usage.

5.2. EXPERIMENTAL DETAILS

In this study, various dosimetry equipment and materials were employed, including TL Dosimeters, TLD reader (Thermo Fischer Scientific, Model 3500), OSL Dosimeter (LANDAUER microSTAR), OSLD Reader, tissue equivalent build-up material (cured transparent gel - 30 cm x 30 cm x 1.0 cm), ionization chamber, RW3 solid water phantom (30 × 30 cm², thickness range 0.1–1 cm, density 1.045 g/cm³), UNIDOS E Electrometer (PTW, Freiburg, Germany), and a 6 MV Linear accelerator (Versa HD, ELEKTA MS). Details are given in the table 5.1.

Table 5.1. Type and physical parameters of dosimeters used for measurements

Instrument, Make & Model	Type	Physical Parameter
TLD-ThermoFischer Scientific - TLD-100	LiF:Mg,Ti	3mm dia x 0.2 mm thick Dots
OSLD-nanoDotTM, Landauer Inc	Al ₂ O ₃ :C	4mm dia x 0.2 mm thick Dots
Ionizing chamber- PTW Freiburg, Germany, 30013	Ionization Based Dosimeter	0.6 cc Volume chamber

The tissue equivalent build-up material, composed of a cured transparent gel, was used to ensure maximum dose deposition in the location where the LD materials were placed. This material also minimized the presence of an air gap between the build-up region and the backscattering phantom, offering flexibility for precise LD positioning and minimizing set-up deviations.

The LD materials were calibrated using the clinical energy of the Linear accelerator (Versa HD, Elekta MS), with careful measurements and calibration of the radiation beam profile and machine output to ensure minimal variation across the irradiation field. This calibration was confirmed using the Radiation Field Analyser

system (RFA, PTW Germany) and 0.6 cc ionization chambers traceable to the reference standard laboratory (RSD, AERB, Mumbai, India) (15). The field profile was adjusted to achieve a uniform dose distribution with a variation of only 2%. A batch calibration was performed to determine the Element Correction Coefficient (ECC) for the LD material (16-18).

For TLD, the reader's PMT (Photomultiplier tube) was operated at a voltage range of 850 V for a good signal-to-noise ratio. A specific time-temperature profile was maintained to record the thermoluminescence glow curve and the integrated thermoluminescence light output. Annealing of the TL dosimeter was carried out at 400°C through an annealing process (18-21). A sensitivity factor (Element Correction Coefficient) was determined for all TL dosimeters with known doses, and a calibration curve was created for the dose range from 25 cGy to 600 cGy. The calibration details are given in the figure 4.8 (Chapter 4).

Similarly, OSLD readers were quality tested before each process, and OSL dosimeters were bleached under high-intensity light before exposure. Sensitivity correction was applied for all OSL dosimeters, and a calibration curve was formed for a similar dose range to TL dosimeters as in figure 4.9 (Chapter 4).

The study utilized a CT simulator (GE Optima PETCT) to scan the configuration of TL and OSL dosimeters sandwiched between a slab phantom with 10 cm and 1.5 cm build-up bolus set-up. The data from the CT simulator was transferred to the treatment planning system (VARIAN Eclipse TPS, Version: 16.00). Various treatment plans were created with gantry angles ranging from 0° to $\pm 90^\circ$ at an increment of 10°, and the field size varied from 10 x 10 cm² to 30 x 30 cm² with symmetric openings to the central axis. Dose calculations were performed in the TPS at the level of dosimeters placed to normalize 100 cGy at a 100 cm source-to-axis distance (SAD) set-up. The setup has been given the following figures 5.1 - 5.2.

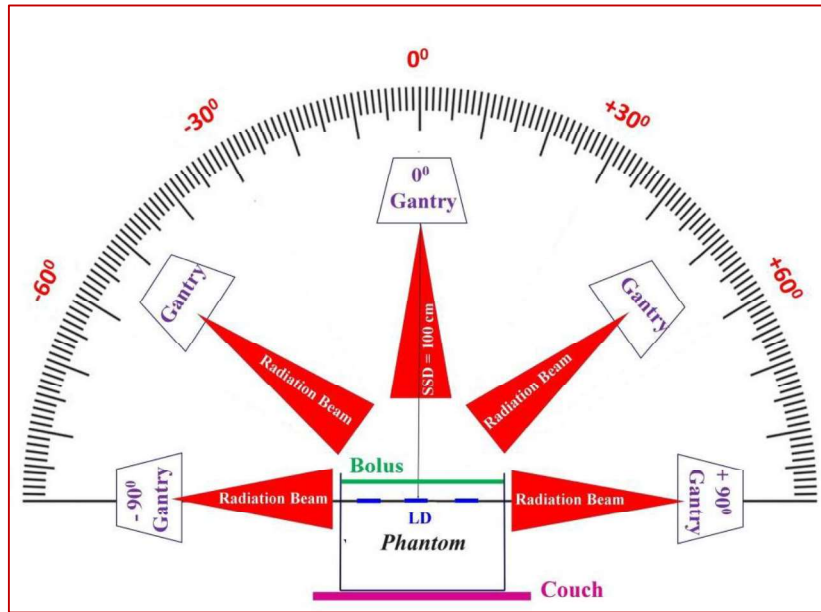


Figure 5.1. Schematic illustration of irradiation set up.

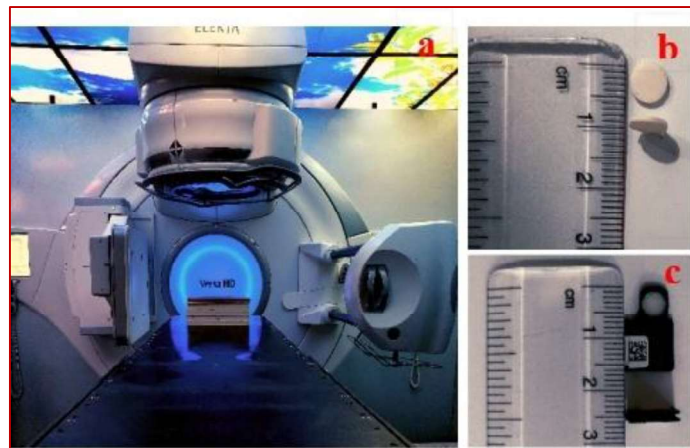


Figure 5.2. (a) Irradiation set up, (b) TLD, (c) OSLD.

A grid pattern of five dosimeters was placed in each set-up, one at the isocenter and the remaining at 1 cm to the right, left, superior, and inferior to the central dosimeter as in the figure 5.3, to account for off-axis dose variations. This set-up was repeated for each gantry angle, using 285 TLDs and 285 OSLDs, totaling 570 dosimeters irradiated throughout the entire process.

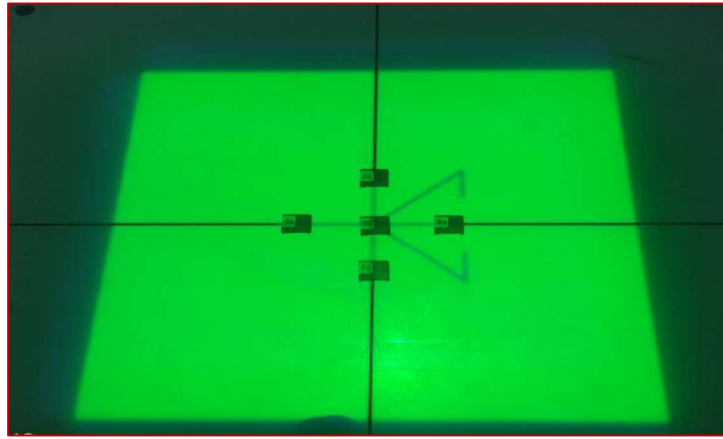


Figure 5.3. Dosimeter alignment in the radiation light field

The planned set-up was transferred to the linear accelerator using an interface software called MOSIQ, and irradiation was conducted under measured atmospheric conditions (21°C and 101.3 kPa). Gantry and collimator settings were adjusted to the planned position for each exposure during both TL dosimeter and OSL dosimeter measurements (22, 23).

After exposure, the dosimeters were stored for one hour in a safe environment, and then the standard reading procedure was applied using the appropriate LD reader for each dosimeter type. The results were analysed separately for each dosimeter (19,20).

5.3. RESULT AND DISCUSSION

In this study, the readout results of TL dosimeters for various gantry angles and field sizes were analysed using a TL dosimeter reader and a calibration graph. The result from perpendicular radiation incidents with a field size of 10 x 10 cm² was taken as a normalized reference value for comparison. For the grid of five dosimeters, the average result of these five dosimeters was plotted on the graph.

The dose response analysed here represents the variation in dose from the planned dose calculated through the Treatment Planning System (TPS) to the actual dose at the position where the TL/OSL dosimeters are placed (true dose). The individual variations in dose measurements from the mean are presented as standard deviations in the graph. The comparison between TL and OSL dosimeters was performed for all gantry angles and nominal field sizes used in the clinical range, particularly for surface dose measurements during conventional breast irradiation. The study covered field sizes from 10 cm² to 30 cm², addressing this specific issue. In total, 570 irradiation measurements were conducted in this study, excluding the calibration measurements.

Figures 5.4 and 5.5 illustrate the dose-response variation of LDs for a field size of $10 \times 10 \text{ cm}^2$ and $15 \times 15 \text{ cm}^2$, while Figures 5.6 and 5.7 show the variation in dose-response for field sizes of $20 \times 20 \text{ cm}^2$ and $30 \times 30 \text{ cm}^2$, respectively.

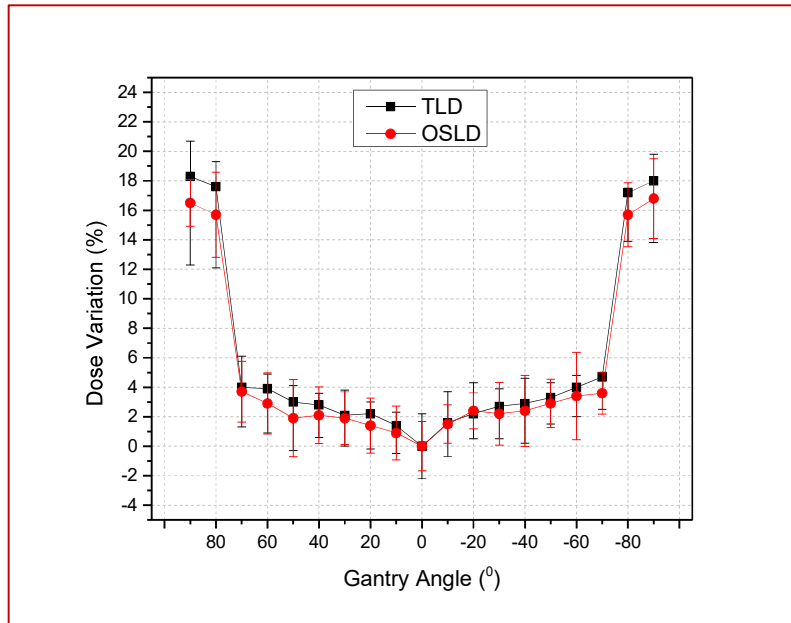


Figure 5.4. Response of TLD and OSLD to the various gantry angles for the $10 \times 10 \text{ cm}^2$ Field size.

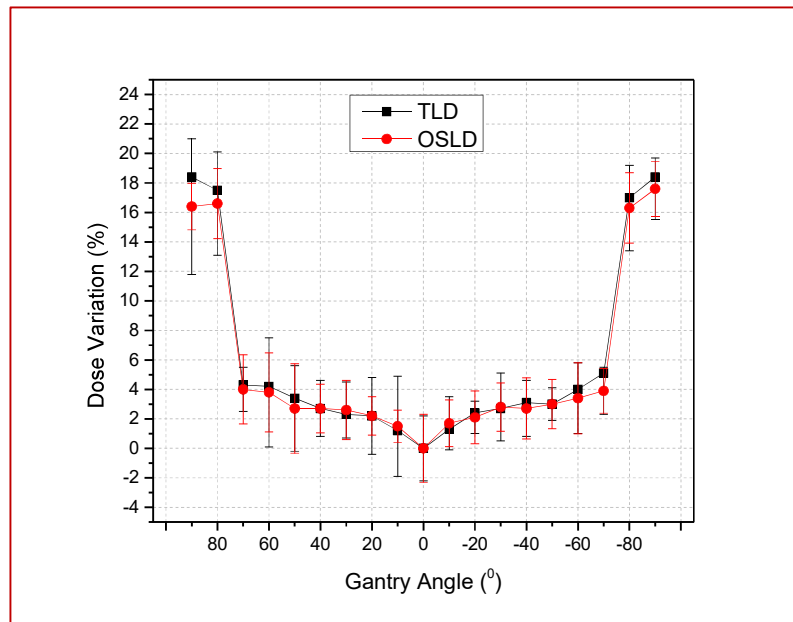


Figure 5.5. Response of TLD and OSLD to the various gantry angles for the $15 \times 15 \text{ cm}^2$ Field size.

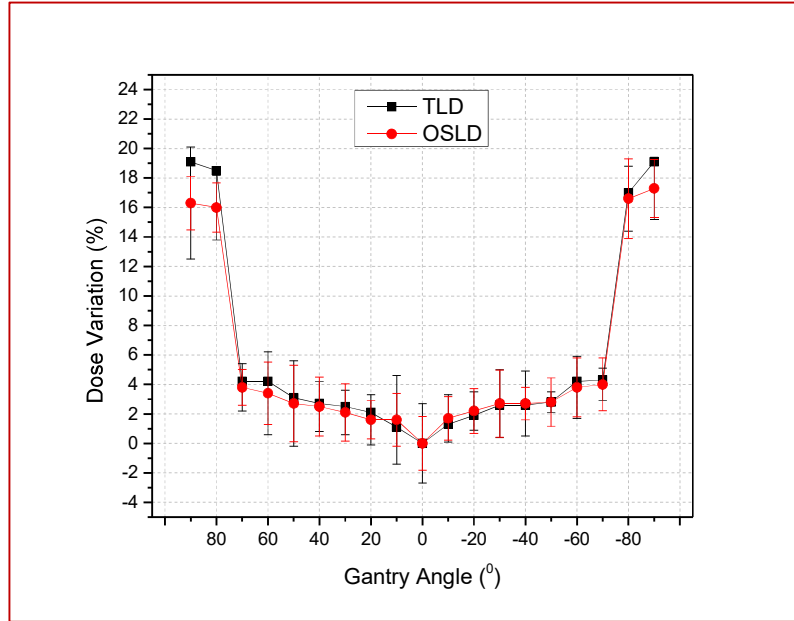


Figure 5.6. Response of TLD and OSLD to the various gantry angles for the 20x20 cm² Field size.

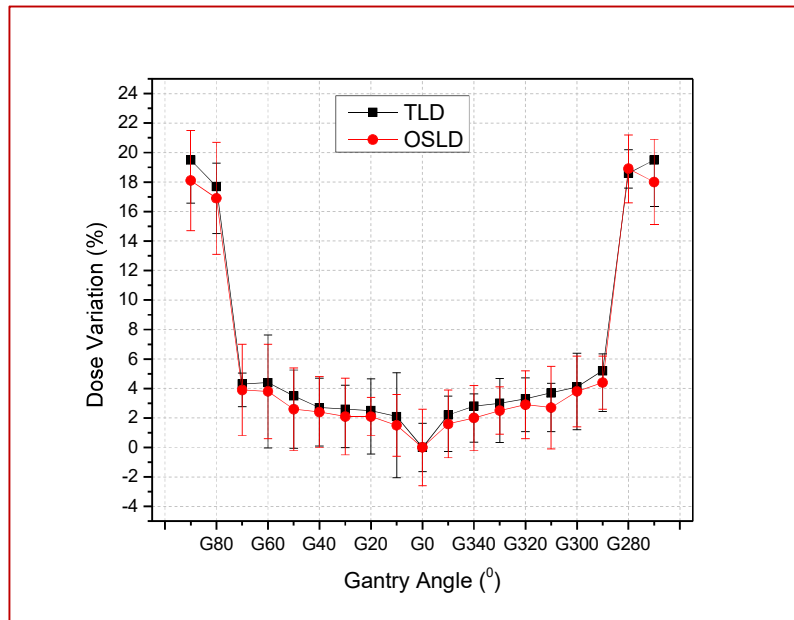


Figure 5.7. Response of TLD and OSLD to the various gantry angles for the 30x30 cm² Field size.

The overall differences are tabulated in the table 5.2 and 5.3 below

Table 5.2. The average dose deviation of OSLD for all field sizes

OSLD		Gantry Angle (O^0)					
Average dose difference	F S (cm^2)	0-40	40-70	80-90	0-(-40)	(-40)-(-70)	(-80)-(-90)
	10	1.27	2.67	16.1	1.71	3.09	16.25
	15	1.82	3.34	16.48	1.88	3.29	16.94
	20	1.58	3.14	16.14	1.88	3.37	16.95
	25	2.06	3.63	16.73	1.96	3.68	17.69
	30	1.64	3.17	17.49	1.83	3.45	18.41
Standard Deviation		0.29	0.35	0.57	0.09	0.22	0.83

Table 5.3. The average dose deviation of TLD for all field sizes

TLD		Gantry Angle (O^0)					
Average dose difference	F S (cm^2)	0-40	40-70	80-90	0-(-40)	(-40)-(-70)	(-80)-(-90)
	10	1.71	3.45	17.99	1.9	3.76	17.64
	15	1.69	3.68	17.98	1.91	3.83	17.72
	20	1.69	3.58	18.8	1.69	3.5	18.04
	25	1.63	3.2	19.37	1.55	3.25	18.21
	30	1.99	3.75	18.61	2.27	4.1	19.06
Standard Deviation		0.14	0.21	0.59	0.27	0.32	0.57

The dosimeter responses for central axis deviation were categorized into gantry angles of 0^0 to 30^0 , and presented in Table 5.4-5.6 for field sizes ranging from $10 \times 10 \text{ cm}^2$ to $30 \times 30 \text{ cm}^2$.

Table 5.4. The average off axis deviation of TLD and OSLD for 10 cm^2 Field size.

LD material	Average Deviation in 0^0 - 30^0	Average Deviation in 30^0 - 60^0	Average Deviation in 0^0 - (-30^0)	Average Deviation in -30^0 - (-60^0)	Average Deviation in -60^0 - (-90^0)	Average Deviation in 60^0 - 90^0
TLD	0.76	0.00	1.61	0.76	0.66	-0.63
OSLD	0.01	0.38	-0.19	-0.50	-0.12	1.61

Table 5.5. The average off axis deviation of TLD and OSLD for 20 cm² Field size.

LD material	Average Deviation in 0°-30°	Average Deviation in 30°-60°	Average Deviation in 0°-(-30°)	Average Deviation in -30°-(-60°)	Average Deviation in -60°-(-90°)	Average Deviation in 60°-90°
TLD	0.52	0.01	-0.21	-0.12	-0.13	0.46
OSLD	0.15	0.26	0.08	0.16	1.04	0.72

Table 5.6. The average off axis deviation of TLD and OSLD for 30 cm² Field size.

LD material	Average Deviation in 0°-30°	Average Deviation in 30°-60°	Average Deviation in 0°-(-30°)	Average Deviation in -30°-(-60°)	Average Deviation in -60°-(-90°)	Average Deviation in 60°-90°
TLD	0.76	0.01	2.11	1.54	-0.24	0.53
OSLD	-0.13	-1.15	0.19	0.65	0.53	0.97

Some dosimeters from the 5 x 5 grid showed deviations from the overall readings and were excluded from the averaging process, assuming possible readout errors or annealing inadequacies.

For a field size of 10 x 10 cm², the TL dosimeters exhibited a 4% variation from the calculated values for gantry angles of 0° to ±60°, but larger variations (>15%) were observed for the remaining gantry angles (i.e., ±70° to ±90°).

The OSL dosimeter readout results showed a 3.6% variation for 10 x 10 cm² and 3.8% for 20 x 20 cm² for gantry angles of 0° to ±70°, but larger variations (>11%) were noted for the remaining gantry angles (i.e., ±80° to ±90°). For the 30 x 30 cm² field size, the results were 3.9%, with larger variations (>13%) for the remaining gantry angles (i.e., ±80° to ±90°).

As shown in Figures 5.6 through 5.9, the dose variations for LDs were within the vendor-specified values up to a field size of 30 x 30 cm² and for angular incidents up to ±70°. However, significant variations (>16%) were observed for the remaining gantry angles (i.e., ±70° to ±90°).

These findings suggest that the use of these LDs is justified for angular incidents of radiation up to ±70°, as they approximate the vendor-specified tolerance limits well. The study revealed that there was minimal to negligible variation in the off-central

LDs compared to the centrally placed LD. The individual LD's variation did not show a direct correlation with their placement in relation to the central axis, as demonstrated in the table 5.2 - 5.4.

There was an average 10% reduction in the monitor unit calculated from TPS for increased field size. This effect tended to change the dose deposition in the LD material but was not significant compared to set-up or experimental errors. From the conducted study, it is not evident that the LD material response is affected by the field size, as shown in figure 5.8-5.9. The result showed that there is a minimal to negligible variation of the measured output with the difference in the radiation field. Also, there is no evidence of variation in the dose measurement due to the field size difference in the gantry angle of $\pm 70^\circ$ to $\pm 90^\circ$.

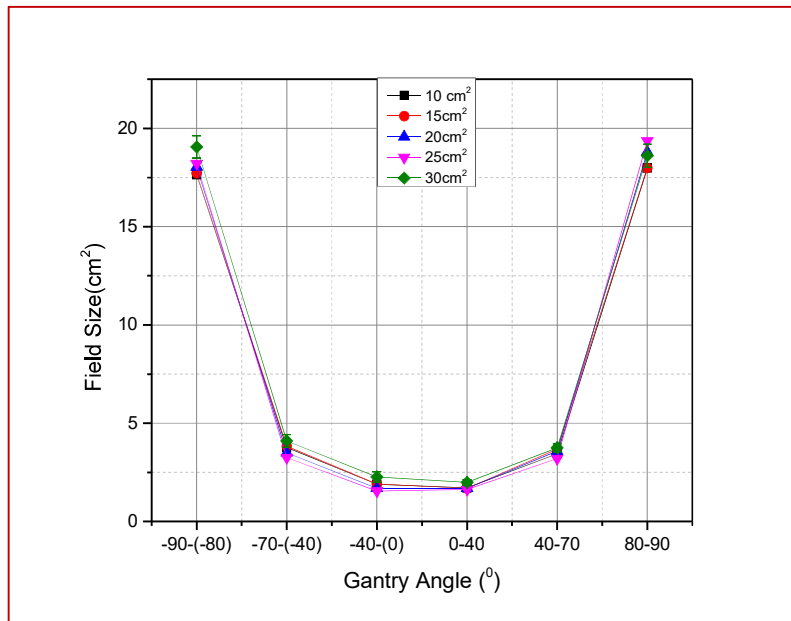


Figure 5.8. Response of TLD to the various Field size.

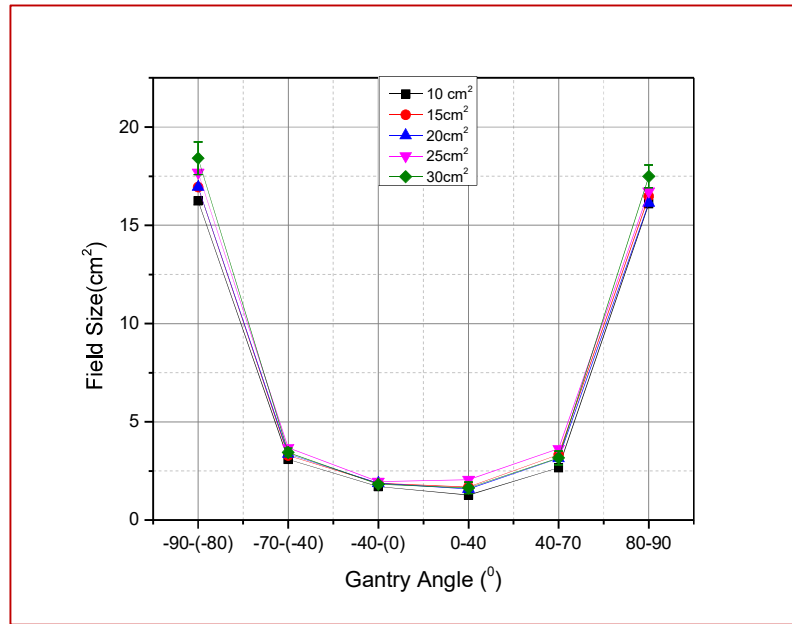


Figure 5.9. Response of OSLD to the various Field size

These results show a good approximation to the vendor-specified tolerance limits and the use of these LDs is justified by the angular incidents of radiation to an extent up to $\pm 70^\circ$ (19-21).

5.4. CONCLUSION

There was a good approximation of dose measurements with both TLD and OSLD for the oblique incidents of radiation to the angle of $\pm 60^\circ$ to $\pm 70^\circ$ respectively. The overall response never dropped beyond the specified values for these gantry angles and different field sizes. There was no over response observed in any of the readings for both TLD and OSLD. An essential aspect of utilizing LD is to avoid any over-response of the dosimeter. Over-response can lead to conflicts with the TPS algorithms used to calculate radiation doses, resulting in inaccurate treatment planning. Additionally, an over-response of the dosimetry can lead to inaccurate treatment care for the patient. The variation in the highly oblique beam could be attributed to the inadequate interaction in the LD material for the edge-on incidents and the scattering from those edges. This may be due to the geometry of the commercial disc form of the LD material as it can introduce angular dependence on edge on irradiation.

The dose difference observed in the OSLD measurements was maximum at 3.65 for field sizes ranging from 20 cm² to 30 cm², with a minimum difference of 1.27. In contrast, the TLD measurements recorded a maximum difference of 4.10 and a minimum of 1.55 for the same field size ranges. These results suggest that OSLD slightly outperforms TLD in terms of application and stability, likely due to the higher

sensitivity of $\text{Al}_2\text{O}_3\text{: C}$ compared to LiF:Mg,Ti . Additionally, the study noted a maximum dose deviation of 1.2 and a minimum of 0.01 between the central dosimeter and the off-axis dosimeter for OSLD, while TLD showed a larger deviation of 3.43 and 0.11. This comparison highlights the advantages of OSLD in clinical settings, especially where precision and sensitivity are crucial. The superior stability and lower deviation in OSLD measurements could be attributed to the material properties of $\text{Al}_2\text{O}_3\text{: C}$ making it a more reliable choice in certain dosimetric applications.

The problem of increased interaction due to the reaction range in the medium cannot be avoided and the same has been accounted for by the vendors with the tolerance limit. The angular dependency issue can be solved with proper handling and accurate measurements. In the present study, both dosimeters showed good approximation to the vendor specified tolerance to the conventional range of angular treatment. I.e. up to $\pm 60^\circ$. However, beyond this range, a significant variation in the measurement was observed, indicating the dosimeter's limitations in these circumstances.

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CHAPTER 6

SURFACE DOSE MEASUREMENT AND COMPARISON BETWEEN TLD AND OSLD DURING MODIFIED RE CONSTRUCTIVE MASTECTOMY IRRADIATION

- 6.1. GENERAL INTRODUCTION
- 6.2. EXPERIMENTAL DETAILS
- 6.3. RESULT
- 6.4. DISCUSSION
- 6.5. CONCLUSION
- 6.6. REFERENCES

CHAPTER 6

SURFACE DOSE MEASUREMENT AND COMPARISON BETWEEN TLD AND OSLD DURING MODIFIED RE CONSTRUCTIVE MASTECTOMY IRRADIATION

6.1. GENERAL INTRODUCTION

Radiotherapy (RT), combined with surgery and chemotherapy, plays a crucial role in breast cancer treatment (1-3). It plays a significant role in the management of breast cancer, especially when the disease is detected early, contributing to improved survival rates. However, breast irradiation can lead to both acute and late side effects such as skin reactions, pain, and heaviness in the breast (4-6). Many studies have suggested that these side effects result from uneven dose distribution within the target area (7-10). Therefore, ensuring uniformity in the radiation dose throughout the treatment volume is essential for effectively treating tumours and minimizing adverse side effects.

The standard approach for breast RT typically includes two parallel opposed tangential radiation fields for the chest wall (CW) followed by a supra clavicular field (SCF) (11). These parallel opposed tangential fields are designed to ensure adequate dose coverage of the treatment area while reducing radiation exposure to nearby healthy structures such as the heart, lungs, and opposite side breast, thus minimizing potential side effects and complications. The likelihood of developing secondary cancer increases as the received radiation increases (12, 13). Therefore, it is essential to measure the doses delivered to nearby normal organs.

Luminescent dosimeters (LDs), particularly Thermo luminescent dosimeters (TLD) and optically stimulated luminescent dosimeters (OSLD) are well suited for in vivo dosimetry (14-17). These dosimeters are preferred for their compact size, high spatial resolution, and wide dose-response range capabilities (18-21).

In the current study, TLD and OSLD were employed to assess the surface dose uniformity during the entire irradiation and to compare the performance of the LD for better clinical applications. These measurements were crucial for several reasons. First, they primarily predict skin reactions (4-6), which help anticipate and monitor potential skin side effects that may occur as a result of radiation therapy, allowing healthcare providers to take preventive or corrective actions when necessary. Second, by assessing the dose accuracy by comparing the measured surface dose with the planned dose, healthcare professionals can verify that the treatment is being delivered as planned. Any

discrepancies can be addressed to ensure that the patient receives a prescribed radiation dose. In summary, measuring the surface dose with radiation dosimeters is a valuable practice in radiation therapy as it aids in both patient safety and treatment effectiveness.

6.2. MATERIALS AND METHODS

In this study, 100 patients received 3 dimensional conformal radiotherapy (3DCRT) for modified re constructive mastectomy (MRM) chest wall irradiation were included. The patients were scanned using a CT scanner under special immobilization conditions. Organ delineation and Planning Target Volume (PTV) contoured in a treatment planning system (TPS) (MONACO TPS by Elekta MS). Tangential beams were positioned for the chest wall and oblique beams were placed for SCF based on the contoured PTV, and dose calculations were performed using the Anisotropic Analytical Algorithm (AAA algorithm) (9,11). The surface dose from the calculated plans was measured using a dose profile measurement tool and recorded. The original plan was then transferred to the treatment machine using the Mosaiq (Elekta MS) interface software.

Ethical clearance from the Institute and University was obtained as this work involves in vivo analysis of the patient (DYPMCK/12/2022/IEC) (HCG/SRC/01/2022).

The prescribed dose was 4250 centi Gray (cGy) delivered in 16 fractions for all patients at a dose of 266 cGy per fraction regime. The treatment fields were placed isocentrically to the entire PTV (CW and SCF) using the half-beam block method, where the field was blocked between CW and SCF. The average Gantry angle for the radiation beam were $\pm 55^0$ tangential to the breast curvature

The Thermo Fischer Scientific TLD reader (Model 3500), the LANDAUER microSTAR OSLD, and an OSLD Reader were used. Table 6.1 provides detailed information on these dosimeters.

Table 6.1. Type and physical parameters of dosimeters used for measurements

Instrument, Make & Model	Type	Physical Parameter
TLD-ThermoFischer Scientific - TLD-100	LiF:Mg,Ti	3mm dia x 0.2 mm thick Dots
OSLD-nanoDotTM, Landauer Inc	Al ₂ O ₃ :C	4mm dia x 0.2 mm thick Dots
Ionizing chamber- PTW Freiburg, Germany, 30013	Ionization Based Dosimeter	0.6 cc Volume chamber

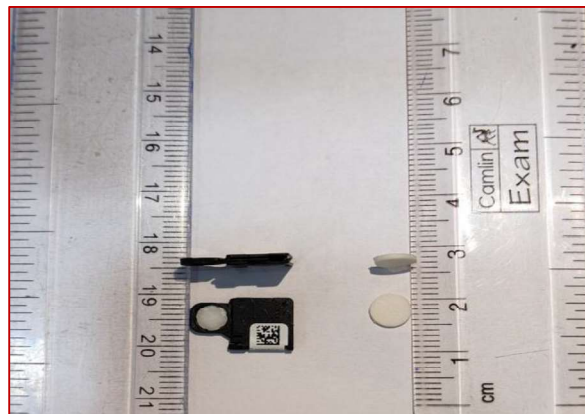


Figure 6.1. The LD materials (TLD and OSLD)

For irradiation during regular patient treatment, a 6MV Linear accelerator (Versa HD, ELEKTA MS) was employed. The output of the linear accelerator was calibrated from 100 monitor units (MU) to 100 cGy using a 0.6 cc ionization chamber and an electrometer in a solid water phantom at a source-to-surface distance (SSD) of 100 cm (20).

The TLD dots (Figure 6.1) were annealed at 400°C using the prescribed annealing process. The sensitivity factor (Element Correction Coefficient) was determined for all TLDs with known doses (15, 16), and a calibration curve was established for doses ranging from 25 to 600 cGy (Figure 6.2).

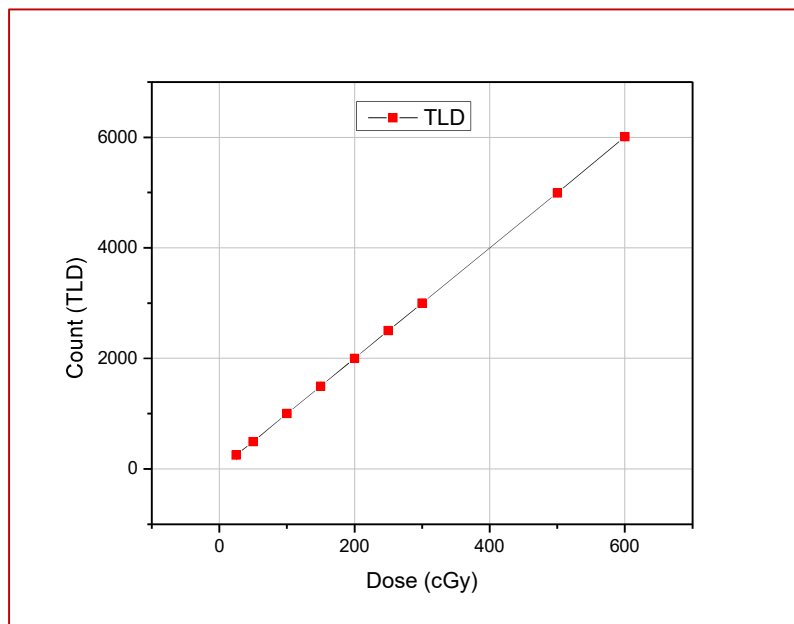


Figure 6.2. The calibration curve for TLD

Similarly, the quality of the OSLD reader was tested before each procedure (21-23), and the OSL dosimeters were bleached under high-intensity light before exposure. Sensitivity correction was applied to all the OSL dosimeters, and a calibration curve was created for a dose range similar to that of the TLD dosimeters (Figure 6.3).

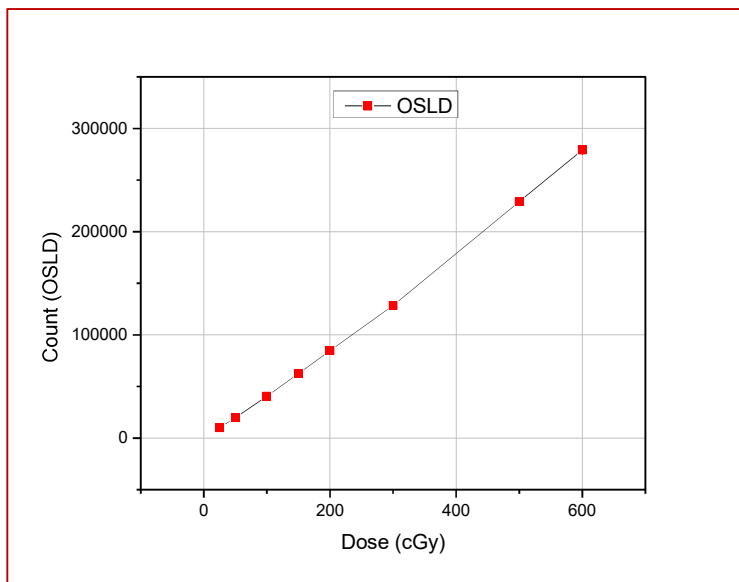


Figure 6.3. The calibration curve for OSLD

Background correction was omitted because the experimental setup fell within the therapeutic range of radiation dose (200 cGy-2666 cGy) in accordance with the American Association of Physicists in Medicine (AAPM) guidelines (14).

In each setup, a grid pattern of five dots was positioned, with one at the center of the CW and the remaining four dots located 3 cm to the right, left, superior, and inferior to the central dot. This setup was repeated for all patients and for both OSLD and TLD dots as in the figure 6.4.



Figure 6.4. LD Positions on the body

Five dosimeters per patient $\times$ 50 patients for each dosimeter type were used; therefore, 250 TLD and 250 OSLD dots were exposed throughout the entire process. The overall procedure of dose measurements performed for the chest wall area only as the size of the SCF is competitively small and there are difficulties in positioning the dosimeter due to the highly irregular anatomical structure.

The exposed dosimeters were stored safely for one day to obtain optimal results and were subsequently subjected to the standard reading procedure using a dedicated reader for each type of dosimeter. The results were analysed separately for each dot.

6.3. RESULTS

The analysis examines how the dose differs from the originally planned dose, which is determined using the TPS, to the actual position where the TL/OSL dosimeters are positioned to measure the true dose. The graph represents the individual differences in the dose measurements from the average, and these differences are depicted as the standard deviation. This comparison between TL and OSL dosimeters was performed for all 100 patients and dosimeters typically employed in clinical settings.

The TLD readout results were analysed using a TLD reader and a calibration graph. The result showed a good approximation with a vendor-specified tolerance limit

of 5%. In the grid of five dosimeters, the result was taken as the average of these five dosimeters and plotted on a graph (Figure 6.5).

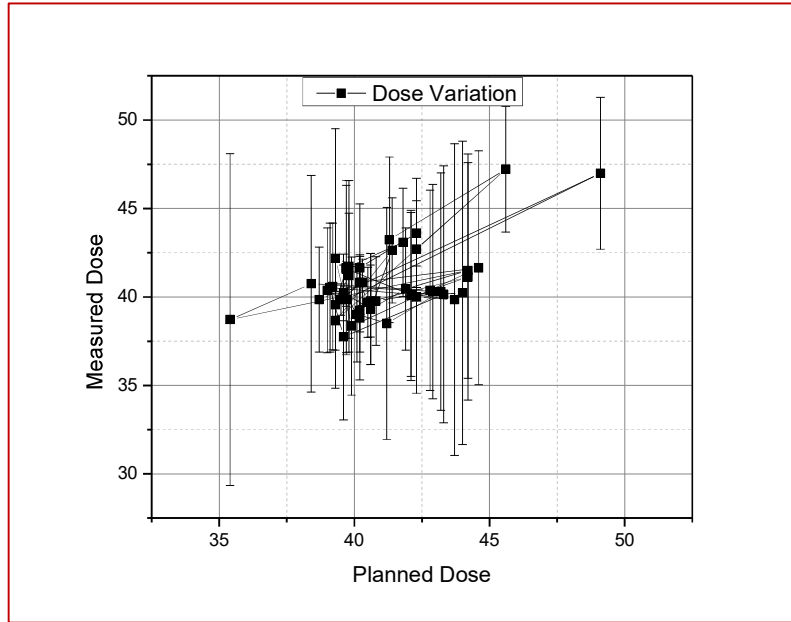


Figure 6.5. Dose variation for TLD

Similarly, OSLD readout results were analysed with the help of an OSLD reader, and the calibration graph and the results were close to the standard surface dose detected by most of the research papers and well within the vendor-specified limit of 5.5%. The average dose values of the five dosimeters were used for analysis and plotted on a graph (Figure 6.6).

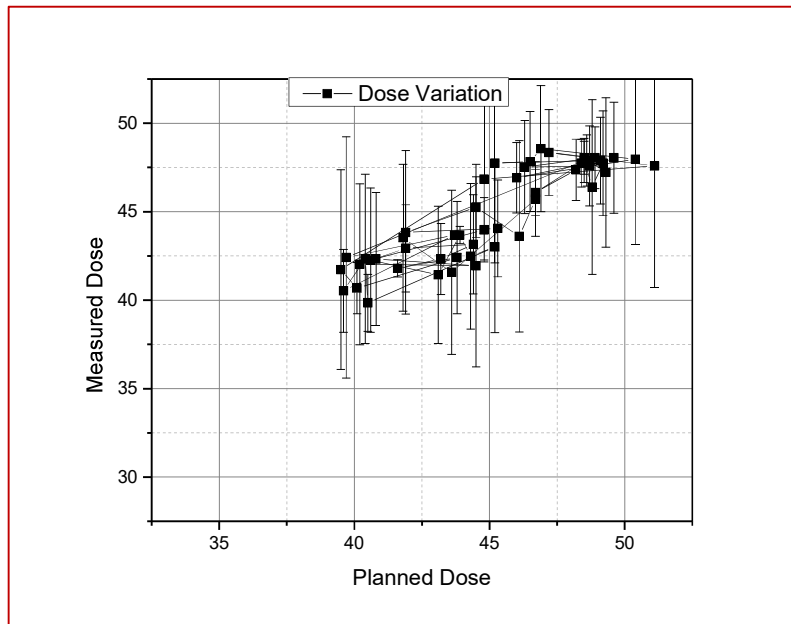


Figure 6.6. Dose variation for OSLD

The spatial dose dependence of off axis dosimeters to the central dosimeter analysed for both TLD and OSLD and provided in the table 6.2.

Table 6.2. The average off axis deviation of TLD and OSLD

LD material	Average Central Dose (cGy)	Average OA Dose (cGy)	Average Dose Difference (cGy)	Average Maximum Difference (cGy)	Average Minimum Difference (cGy)
TLD	112	107.3	-3.75	5	2
OSLD	123	106.2	-2.94	6	0

Some dosimeters from the 5×5 grid showed deviation from the overall readings, and that reading was omitted from the averaging process, assuming that readout errors occurred because of handling or inadequate annealing.

6.4 DISCUSSION

The study aimed to assess the surface dose response of LD, in the context of MRM irradiation. A total of 250 TLD and 250 OSLD were exposed during the treatment and analyzed individually. TL dosimeters showed a maximum of 7.33% and minimum of 0.38% variation from the planned dose at the point with an average difference of 3.85%. The OSL dosimeters showed a maximum of 6.82% and a minimum of 0.04% variation from the planned dose at the point with an average difference of 3.15%.

The study identified a maximum dose deviation of 6cGy and a minimum of 0cGy between the central and off-axis dosimeters for OSLD, while TLD exhibited a deviation range, with a maximum of 5cGy and a minimum of 2cGy.

These results closely align with the tolerance limits specified by the device vendor, suggesting that the use of these luminescent detectors is well founded, especially considering the varying angles of radiation incidence during MRM irradiation. The readout process for the TLD was lengthy compared with that of the OSLD. As the identification of each OSLD was predefined with the help of a barcode scanner and software, the TLD must be measured manually for each dosimeter.

While the study identified a slight variation in dose measurements between TLD and OSLD, it was concluded that both types of detectors could effectively serve as dosimeters for assessing the surface dose during MRM breast irradiation. Different studies stated the surface dose during breast irradiation in the range of 31- 80% depending upon the technique used (24-26).

This study highlights the reliability and applicability of luminescent detectors in the specific context of MRM irradiation, providing valuable insights for ensuring accurate dose measurements and patient safety during this medical procedure.

6.5. CONCLUSION

There was a good approximation of dose measurements with both TLD and OSLD during surface dose measurements in breast irradiation. The post-irradiation process was slightly easier for the OSLD readout than for the TLD. The variation in the highly oblique beam could be attributed to the inadequate interaction in the LD material for edge-on incidents and scattering from those edges. This may be due to the geometry of the commercial disc form of the LD material, which can introduce angular dependence on the edge on irradiation. A minimal to negligible variation in surface dose was observed due to the angle of incidence in this study.

The introduction of LDs in radiotherapy is of great importance in in vivo dosimetry and demands high accuracy in dose measurements. The introduction of radiation for therapeutic purposes may be due to various angles, and surface dose measurement during this procedure will provide a beneficial change needed for better results.

From these procedures, it is observed that it is essential to have a stable and reproducible process in the TLD/OSLD readout to minimize variations in the system response.

Surface dose measurements during breast irradiation showed a close approximation of dose measurements using both TLD and OSLD. When comparing TLD and OSLD, the post-irradiation process was found to be relatively simpler for the OSLD readout. The variation in highly oblique beams can be linked to inadequate interactions in the LD material when exposed at an edge-on angle, along with scattering from the edges. This phenomenon might be attributed to the geometric characteristics of the commercial disc-shaped LD material, which introduce angular dependence in edge-on irradiation scenarios. The incorporation of LDs into radiotherapy is critically important for in vivo dosimetry, necessitating precise and accurate dose measurements.

Therapeutic radiation can be administered from various perspectives, making surface dose measurements a valuable tool for improving treatment outcomes. From the procedures carried out, it is evident that maintaining a stable and reproducible TLD/OSLD readout process is essential to minimize variations in the system response. Achieving precise dose measurements is crucial in breast irradiation. Both TLD and OSLD offer reliable options for measuring the surface doses during breast irradiation. OSLD is more user-friendly in the post-irradiation phase than TLD. The challenges in highly oblique beam scenarios highlight the need for improved LD-material interactions. The geometry of LD materials, particularly in the disc form, can introduce angular dependence in edge-on irradiation scenarios. Incorporating LDs into radiotherapy is of great significance for in vivo dosimetry, which requires high accuracy in dose measurements.

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CHAPTER 7

**SUMMARY AND
CONCLUSION**

CHAPTER 7

SUMMARY AND CONCLUSION

Radiotherapy (RT) stands as a cornerstone in the comprehensive treatment of breast cancer, playing a pivotal role in significantly enhancing survival rates. However, the efficacy of RT is intricately linked with the precision of dose delivery. The application of controlled doses of radiation post-surgery has demonstrated a profound impact on patient outcomes, contributing substantially to increased survival rates and decreased rates of recurrence. Despite its indisputable benefits, the precision of dose delivery remains a pivotal factor in mitigating potential side effects, as any disparities in dose distribution can manifest as both acute and late side effects. The current study delves into capabilities of luminescent dosimeters (LDs), with a specific focus on Thermo luminescent dosimeters (TLD) and Optically Stimulated Luminescent dosimeters (OSLD).

In Chapter I, the fundamental elements of the research project are presented, focusing on the essential aspects of radiation therapy (RT). The chapter delves into the discussion of the basic concept of RT, specifically exploring the application of LD for the surface dose measurement during the treatment of breast cancer using LINAC and detailing the associated methodology. A comprehensive literature review has been conducted, offering an in-depth exploration of the existing body of knowledge in this field.

The chapter also provides a concise overview of radiation dosimetry and outlines the methods employed in breast irradiation. The scope of the research work is expounded upon, along with a detailed explanation of the specific requirements for conducting this investigation.

Furthermore, the chapter outlines two primary objectives that guide the research. The first objective aims to assess the accuracy of the angular response of Optically Stimulated Luminescent Dosimeters (OSLD) and Thermoluminescent Dosimeters (TLD), emphasizing a comparative analysis between the two. The second objective involves the utilization of TLD and OSLD for in vivo surface dose measurements in post Modified Radical Mastectomy (MRM) breast irradiation. The effectiveness of these dosimeters in measuring doses is examined, providing a basis for comparison between the two methods. The scope of the research work and the requirement of this particular research has been elaborated here.

In Chapter II, the focus is on an in-depth exploration of the theory surrounding Optically Stimulated Luminescent Dosimeters (OSLDs). The chapter extensively discusses the fundamental concepts related to OSL dosimeters, including the properties of OSLDs and the methodologies employed in their calibration and dose measurement.

OSLDs are a particular type of dosimeter characterized by their ability to release stored energy when exposed to specific light input. The discussion emphasizes the suitability of OSL dosimeters for dosimetry in the context of Radiation Therapy (RT), particularly in the realm of in vivo dosimetry. The study specifically utilizes OSLDs for surface dosimetry during breast RT, recognizing the critical importance of measuring surface doses due to the inherent heterogeneity in patient anatomy and the unique beam entry characteristics during RT.

The chapter further elucidates the procedure for dose measurement using OSLDs and provides a comprehensive examination of the calibration process for OSLD nano dots. This detailed discussion establishes the groundwork for the entire research project, as the outlined methods are consistently followed throughout the study. The emphasis on OSLDs and their calibration underscores their significance in achieving accurate and reliable dose measurements, particularly in the complex and varied environment of breast RT.

Chapter III delves into a thorough exploration of the theory behind Thermoluminescent Dosimeters (TLDs). This section of the research work provides an in-depth discussion on the fundamental concepts related to TLDs, including the properties of these dosimeters and the methodologies employed in their calibration and dose measurement.

TLDs, as a type of dosimeter, exhibit the unique property of emitting stored energy when subjected to a specific thermal input. This characteristic makes TLDs particularly well-suited for dosimetry in the context of Radiation Therapy (RT), with a specific emphasis on their application in in vivo dosimetry. In the study at hand, TLDs are employed for surface dosimetry during breast RT, recognizing the crucial need for accurate surface dose measurements due to the inherent heterogeneity in patient anatomy and the specialized beam entry during RT procedures.

The chapter provides a detailed exploration of the procedure for dose measurement using TLDs, and it offers an elaborate discussion on the calibration process for TLD discs. The methods outlined in this chapter serve as a consistent and essential framework for the entire research project, emphasizing the significance of

TLDs in achieving precise and reliable dose measurements in the intricate context of breast RT. The comprehensive examination of TLDs and their calibration underscores their critical role in contributing to the overall success and accuracy of the research findings.

Chapter IV provides a comprehensive discussion of the materials and methods employed in the research work. This section is dedicated to detailing the various materials used in different aspects of the study, with a meticulous examination of each component. Additionally, the calibration process of the Linear Accelerator (LINAC) utilized in the research is thoroughly explained, ensuring transparency in the methodology.

The chapter also explains the calibration procedures for each dosimeter employed in the study. This includes a detailed discussion on the fundamental concept of dosimeter usage during *in vivo* measurements, emphasizing the importance of precise calibration to ensure accurate and reliable dose measurements. The intricacies of the calibration methods are outlined to provide a clear understanding of the steps taken to guarantee the validity of the data collected.

Given the involvement of patients in the study, ethical considerations are paramount. The chapter highlights the ethical clearance obtained from the university and hospital where the research has been conducted. This underscores the commitment to conducting the research in a responsible and ethical manner, ensuring the well-being and rights of the individuals participating in the study.

In essence, Chapter IV serves as a comprehensive guide to the research methodology, offering detailed insights into the materials used, calibration processes, and ethical considerations, thereby providing a robust foundation for the subsequent analysis and interpretation of the research findings.

Chapter V concentrates on a detailed exploration of the angular dependencies of Optically Stimulated Luminescent Dosimeters (OSLDs) and Thermoluminescent Dosimeters (TLDs). Each dosimeter is subjected to an analysis of its angular dependency. The primary objective of this chapter is to assess the performance of the dosimeters under different radiation incidents from various gantry angles. This investigation is particularly pertinent in the context of surface dose measurements, especially in MRM breast irradiation scenarios, resulting in the total removal of the breast. The angular dependency study becomes crucial in ensuring the reliability and accuracy of dose measurements in this unique treatment context.

The observed dose discrepancies in the OSLD measurements reached a maximum of 3.65 for field sizes between 20 cm² and 30 cm², with a minimum variation of 1.27. In contrast, TLD measurements demonstrated a higher maximum discrepancy of 4.10 and a minimum of 1.55 over the same field size range. These findings suggest that OSLD offers slightly better performance in terms of application precision and measurement stability, which can be attributed to the greater sensitivity of Al₂O₃:C compared to LiF:Mg,Ti. Furthermore, the study identified a maximum dose deviation of 1.2 and a minimum of 0.01 between the central and off-axis dosimeters for OSLD, while TLD exhibited a larger deviation range, with a maximum of 3.43 and a minimum of 0.11. This comparison highlights the advantages of OSLD in clinical settings, especially where precision and sensitivity are crucial. The superior stability and lower deviation in OSLD measurements could be attributed to the material properties of Al₂O₃:C making it a more reliable choice in certain dosimetric applications.

Chapter VI focuses on the practical application of dosimeters in surface dose measurements specifically during MRM breast irradiation. The chapter discusses on comparative analysis of dosimeters during MRM irradiation, exploring variations observed in dose measurements based on the dosimeter's placement and radiation beam entry.

Detailed reports on the dosimeter comparison during MRM irradiation are presented in this chapter. The variations in measurements attributed to the placement of dosimeters are systematically tabulated, providing a comprehensive overview of the suspected differences and their potential implications for accurate dose assessments.

The TL dosimeters exhibited a maximum variation of 7.33% and a minimum variation of 0.38% from the planned dose at the specified measurement points, with an average difference of 3.85%. In comparison, the OSL dosimeters displayed a maximum variation of 6.82% and a minimum of 0.04% from the planned dose, with an average difference of 3.15%. Additionally, the study recorded a maximum dose deviation of 6 cGy and a minimum of 0 cGy between the central and off-axis dosimeters for OSLD, whereas the TLD measurements showed a deviation range from a maximum of 5 cGy to a minimum of 2 cGy. This suggests a slightly more consistent performance of the OSLDs compared to the TLDs in terms of dose agreement with the treatment plan and off-axis dose measurements.

The research aims to meticulously evaluate the uniformity of surface dose distribution during MRM breast irradiation, particularly following breast mastectomy.

Luminescent dosimeters emerge as revolutionary tools in the realm of radiotherapy, offering a means to assess and refine dose distribution. The integration of luminescent dosimeters, not only facilitates real-time monitoring of dose distribution but also empowers clinicians to make necessary adjustments to optimize treatment plans. This, in turn, contributes to improved patient outcomes and a higher quality of life post-treatment. In conclusion, the utilization of luminescent dosimeters, as evidenced by the focus on TLDs and OSLDs in this study, represents a transformative approach to enhancing the precision of breast cancer radiotherapy. By honing in on surface dose uniformity following breast MRM surgery, clinicians can refine treatment strategies, thereby mitigating potential side effects and advancing the overall efficacy of radiotherapy in breast cancer care.

It can be concluded from the research that the OSLDs demonstrated greater stability and readability than TLDs, likely due to the higher sensitivity of the $\text{Al}_2\text{O}_3\text{:C}$ material used in OSLDs compared to the LiF:Mg,Ti used in TLDs. Additionally, managing and identifying each OSLD was more convenient, as they were equipped with QR code-based identification, whereas TLDs lacked such individual identifiers, making them harder to track.

The readout process for OSLDs was also simpler and the equipment was more portable and easier to operate compared to that of TLDs. While the annealing process for TLDs was complex and cumbersome, it was straightforward for OSLDs. Overall, OSLDs provided superior results with a more user-friendly readout process, whereas TLDs, though effective, involved more complicated handling and readout procedures.

CHAPTER 8

RECOMMENDATIONS

CHAPTER 8

RECOMMENDATIONS

The study compares the response of individual LDs under clinical scenarios. Understanding the effect of the angular response of the LD is crucial in radiotherapy as accurate measurement of the dose in oblique treatment conditions will help to analyse the surface dose effectively and to give better clinical advice and care. This study is aimed at the performance evaluation of TLD and OSLD on 6 MV clinical photon interactions with various field sizes and angles and compares the performances of both TLD and OSLD to achieve less variation in clinical usage

The initial challenge arising from increased interaction within the medium due to the reaction range is inevitable, and vendors have addressed this by incorporating a tolerance limit. The second issue related to angular dependency can be resolved through careful handling and precise measurements. In the current investigation, both dosimeters demonstrated satisfactory conformity to the vendor-specified tolerance within the conventional angular treatment range (up to $\pm 60^\circ$). However, beyond this range, substantial variations in measurements highlight the dosimeter's limitations. The proposed solutions for this issue are as follows:

A) Typically, tangential beams are exclusively utilized for breast irradiation. The entry of radiation at angles beyond $\pm 60^\circ$ not only leads to angular dependency but also results in the unwarranted irradiation of the contra lateral breast. Therefore, angular incidents beyond $\pm 60^\circ$ lack significance in radiotherapy and should be avoided. In the current study it is observed that dosimeters exhibited a 3.6 - 4% variation from the calculated values for gantry angles of 0° to $\pm 60^\circ$, but larger variations ($>13\%$) were observed for the remaining gantry angles (i.e., $\pm 70^\circ$ to $\pm 90^\circ$).

B) When a radiation field involves angular entry, positioning the LD in such a way that radiation incidents are perpendicular or nearly perpendicular can mitigate errors.

Implementing these recommendations enables manufacturers and researchers to work towards minimizing the impact of angular dependence, thereby enhancing the accuracy of LD measurements, especially in scenarios where radiation incidents occur at non-perpendicular angles during treatment.



International Conference on Medical Physics - 2023

ICMP 2023

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Theme: Innovations in Radiation Technology & Medical Physics for Better Healthcare
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has presented Poster titled

ANGULAR RESPONSE ANALYSIS OF OSLD FOR CLINICAL USE

during 43rd Annual Conference of Association of Medical Physicists of India - AMPICON 2022

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Presentation ID: P-082

Abstract ID: H8689

DOSIMETRIC COMPARISON OF FLATTENED AND UN FLATTENED BEAM FOR HYPOFRACTIONATED VOLUMETRIC ARC RADIOTHERAPY

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AIM/BACKGROUND: The objective of this study was to examine the effects of using flattened (FF) and unflattened (FFF) radiation beams in hypofractionated volumetric Arc radiotherapy (VMAT). The main aim was to explore the characteristics of FFF beams, which exhibit low-dose regions when transitioning from the center to the edges, and to identify the advantages of using FFF beams over FF beams.

MATERIALS & METHODS: We evaluated a group of twenty-two patients who had previously completed treatment with FF VMAT. The prescribed doses were 60Gy/20#s (N0:8) and 55Gy/20#s (N0:14), with the intention of delivering 95% of the target volumes (D95%) at the prescribed dose and achieving a dose homogeneity of 95-107%. The dose rate was set at 600 MU/min for FF plans and 1400 MU/min for FFF plans. The optimization goals and iteration numbers remained the same for both types of plans. The evaluation of treatment volumes focused on the near-maximum dose (D2%), average dose (D50%), and near-minimum dose (D98%) as defined in the protocol outlined in the ICRU 83 Report. The homogeneity index (HI), conformity index (CI) and Gradient Index (GI) were analysed. Also to compare the two types of plans, we assessed the total MU and treatment duration by delivering the plans under phantom conditions.

RESULT: There were no significant disparities observed between the two approaches when examining the D2% (Gy), D98% (Gy), D50% (Gy), HI, and CI. The doses to the OAR were comparable in both plan types. However, FFF plans exhibited a favourable gradient index compared to FF plans. Notably, FFF plans required higher MU than FF plans, demonstrating a significant difference. On the other hand, the utilization of FFF plans led to a substantial reduction in treatment time.

CONCLUSION: Our studies revealed a notable decrease in treatment duration when utilizing the FFF beam compared to the FF beam. This reduction in time is particularly advantageous, considering the high relative biological effectiveness (RBE) of FFF beams, especially in the context of hypofractionated radiotherapy. Additionally, the use of FFF beams can contribute to minimizing errors caused by intra-fractional motion. It is essential to conduct further investigations into the effects of higher monitor units (MU) in VMAT treatment delivery to assess its implications on the prognosis and quality of life of cancer patients.

KEYWORDS: VMAT, Hypo fractionated RT, FFF, FF, Gradient Index



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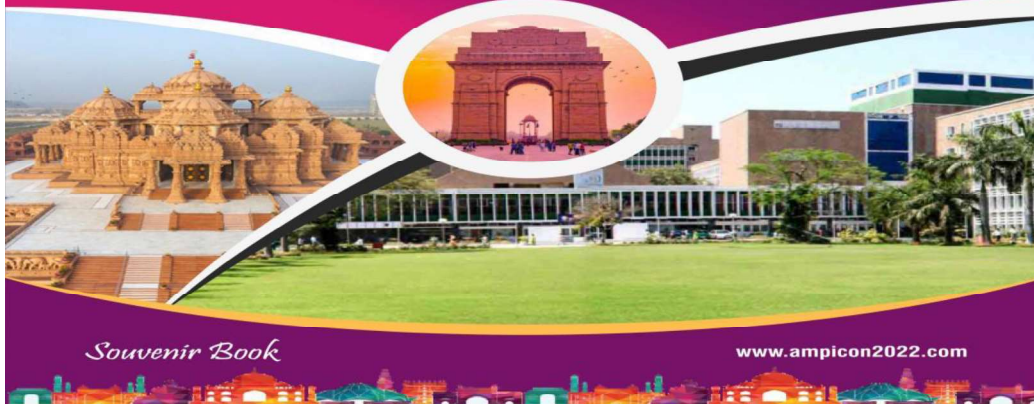
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Abstract ID: 24

Presentation Title: Angular response analysis of OSLD for Clinical Use

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Content

Aim-Background: To analyse the angular response of OSLD (Nano dot; AI203:C) with respect to the various field size and various Gantry angles of a 6 MV photon by Linear accelerator (Versa HD, ELEKTA MS).

Material-Methods: Optically stimulated Luminescence detectors are widely used in clinical practices especially in radiotherapy for personal dosimetry and in vivo dosimetry. The usage of the same has been well established in recent studies as well. The concern while in vivo usage of the OSLD is mainly the responsibility of the dosimeter to the incident beam direction as the special physical geometry of the dosimeter. In this study, the angular response of the OSLD dosimeter is analyzed to the various radiation incident angles and various field sizes from a 6MV photon by Linear Accelerator.

OSLD (Nano dot; AI203:C) were irradiated with a Linear Accelerator (VersaHD, Elekta Medical systems) in a 5 x 5 grid format. The whole set-up was carried out with the help of solid water phantom (PTW, Germany) slabs of a total thickness of 15 cm and a build-up fat bolus of 1.5 cm. The output, PDD and Dmax of the LINAC has been verified before the measurements with the help of RFA (PTW, Germany). The irradiated nano dots were subjected to the readout process with the help of the OSLD reader (LANDAUER microSTAR ii). The procedure was repeated for different field sizes varying from 10 cm x 10 cm to 30 cm x 30 cm and for different gantry angles. The results were analyzed for each set-up.

Results: The nano dots were irradiated with different gantry angles from 90 degrees to 0 degrees and 270 degrees to 0 degrees. The deviation in the output was observed as within 5% for OSLD. A significant deviation from the desired output was observed towards the angle of incidence of 70 degrees to 90 degrees on one side and 290 degrees to 270 degrees on another side. There were some dots that showed deviation from the overall readings, and the same has been omitted from the procedure assuming that occurred due to the procedural error.

Conclusion: The OSLD analysis showed a good dose response towards Gantry angles up to 70 degrees to either side of the perpendicular incidents. The OSLD readout results were good to 5% in different field sizes for gantry angles of 0 degrees to 70 degrees and 0 degrees to 290 degrees and vary largely (>15%) for remaining gantry angles (i.e. 80 degrees to 90 degrees and 280 degrees to 270 degrees). These results show a good approximation to the vendor-specified tolerance limits and the use of these OSLD is justified by the angular incidents of radiation.

Abstract ID: 25

Presentation Title: Theratron Phoenix: Cancer Statistics by 8 Years Patient Data

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Content

Aim-Background: The report aimed to cover the 8-year cancer statistics from Jan 2015 to June 2022 at Dr Sheela Sharma Memorial Charitable Trust at Mathura-281003 (U.P).

Material-Methods: Totally 1385 patient data were analyzed (173.12 patients/Year; 991 Male; 394 Female) with various cancer types. All the patient data in this study are based on the consecutive case histories by the hospital patient chart. We analyzed the characteristics of patients such as gender, age, food habit, various cancer types, Blood pressure, Pulses, Temperature, Blood oxygen levels etc.,

Results: The treated male average age was 52.87 and the female age was 51.75. We observed that the food habit of the peoples includes High sweet and specie. In males, 70% of males are smokers and 75% are tobacco and alcohol takers. Mostly, 19 specific cancer types are being treated repeatedly for the last 8 years in our hospital. The average temperature of the patient were 98F; Pulses were 88/min, Blood pressures were 110/70 mm of Hg, and the Oxygen level of blood was 96SpO2.

In Male, the treatment includes cancer in the Base of the Tongue was 15.64%, buccal mucosa was 9.18%, Lung was 10.49%, Larynx was 9.48%, Tongue was 9.98%, Esophagus was 2.72%, Supraglottitis was 2.72%, Hard Palate was 1.61%, Soft palate was 1.41%, Thyroid was 3.7%, Alveolus was 2.42%, Bladder was 2.32%, Prostate was 2.01%, Astrocytoma was 1.21%, Lip 1.51%, Secondary neck was 2.32%, and Tonsil was 4.43%.

In Female, the treatment includes cancer in Cervix was 25.88%, Breast was 27.66%, Base of Tongue was 2.5%, buccal mucosa was 1.52%, Lung was 2.28%, Larynx was 0.5%, Tongue was 3.04%, Esophagus was 4.82%, Supraglottitis was 0%, Hard Palate was 0.25%, Soft palate was 0.25%, Thyroid was 1.01%, Alveolus was 0.7%, Bladder was 2.03%, Prostate was 2.01%, Astrocytoma was 0%, Lip 0%, Secondary neck was 0%, and Tonsil was 0.7%.

Conclusion: In Male, Cancer in the Base of the Tongue and Lung, Buccal mucosa, Larynx and Tongue was found to be a higher percentage due to their smoking and tobacco usage etc.,

In Female, Cancer of cervix and Breast was found to be a higher percentage due to their lifestyle. Based on these 8 years of cancer treatment experience, Government and Private organizations should create more awareness programs about the early diagnosis of cancer and treatment option with government schemes. Being a Trust hospital in the rural Mathura (U.P) area we also conducting so many awareness programs about cancer treatment and diagnosis. Free food service has also been provided in our hospital for patients for the last 8 months. Also conducting Blood donation camp for needers

Applied Radiation and Isotopes

Angular dependence of the TL and OSL dosimeters in the clinical 6 MV photon Beam --Manuscript Draft--

Manuscript Number:	ARI-D-23-00450R2
Article Type:	Original Paper
Section/Category:	Radiation Measurements
Keywords:	Luminescent dosimeters; Thermo Luminescence Dosimeter; Optically Stimulated Luminescence Dosimeter; Angular response; linear accelerator
Corresponding Author:	Mayakannan Krishnan DY Patil Education Society Institution Deemed to be University Kolhapur INDIA
First Author:	RATHEESH KANJIRATH EDDAM
Order of Authors:	RATHEESH KANJIRATH EDDAM Mayakannan Krishnan
Abstract:	The angular response of luminescent dosimeters (LD), in particular TLD and OSLD, has been compared by applying 6 MV X-ray photons from Versa HD clinical linear accelerator. The study admitted for the irradiation of TLD (n=285) and OSLD (n=285) under phantom set up in various gantry angles from 00 to $\pm 90^\circ$ and various field sizes from 10 x 10 cm² to 30 x 30 cm². The variance in the output was observed between 4.4% for TLD and 3.9% for OSLD. A significant deviation from the desired output was detected, towards the angle of incidents, at $\pm 70^\circ$ to $\pm 90^\circ$. additionally, there is no evidence of variation in the dose measurement due to the difference in field size. These results demonstrate a good approximation to the vendor-specified tolerance limits, justifying the use of these LDs within angular incidents of radiation up to $\pm 70^\circ$. The TLD and OSLD better dose-response is achieved to a gantry angle up to $\pm 70^\circ$ from the perpendicular incidents. The result shows that both TLD and OSLD could be used as dosimeters for a treatment field that does not extend beyond $\pm 70^\circ$ beam angle.
Suggested Reviewers:	Rabi Raja Singh rabiraja@cmvclloire.acin Similar studies Agüero H haguero2626@gmail.com Similar studies
Opposed Reviewers:	



Applied Radiation and Isotopes

Volume 202, December 2023, 111073



Angular dependence of the TL and OSL dosimeters in the clinical 6 MV photon Beam

Ratheesh K.E., Mayakannan Krishnan  

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Surface dose measurement and comparison between TLD and OSLD during modified re constructive mastectomy irradiation

Ratheesh K E ¹, Mayakannan Krishnan ¹

Affiliations + expand

PMID: 38714180 DOI: 10.1088/2057-1976/ad47fd

Abstract

Radiotherapy (RT) is one of the major treatment modalities among surgery and chemotherapy for carcinoma breast. The surface dose study of modified reconstructive constructive Mastectomy (MRM) breast is important due to the heterogeneity in the body contour and the conventional treatment angle to save the lungs and heart from the radiation. These angular entries of radiation beam cause an unpredictable dose deposition on the body surface, which has to be monitored. Thermoluminescent dosimeter (TLD) or optically stimulated luminescent dosimeter (nano OSLD) are commonly preferable dosimeters for this purpose. The surface dose response of TLD and nano OSLD during MRM irradiation has been compared with the predicted dose from the treatment planning system (TPS). The study monitored 100 MRM patients by employing a total 500 dosimeters consisting



D. Y. PATIL MEDICAL COLLEGE KOLHAPUR

Constituent Unit of D. Y. Patil Education Society (Deemed to be University), Kolhapur.
Re-accredited by NAAC with 'A' Grade

Dr. Rakesh Kumar Sharma
Dean & Professor (Obst. & Gyn)

Padmashree Dr. D. Y. Patil
Founder president

Dr. Sanjay D. Patil
President

No. DYPMCK/.....12...../2022/IEC

Date:
24 JUN 2022

INSTITUTIONAL ETHICS COMMITTEE, D. Y. PATIL MEDICAL COLLEGE, KOLHAPUR.

This is to certify that the research project titled,

"Analysis of Angular Dependencies Between OSLD and TLD- Comparison of its In-Vivo Surface dose Measurements for Post Mastectomy Breast Irradiation."

Submitted by : Mr. Ratheesh K. E.

Under the supervision of appointed Guide (if any): Dr. K. Mayakannan

Has been studied by the Institutional Ethics Committee (IEC) at its meeting held on 07/04/2022 and after corrected has granted approval for the study with due effect with the following caveats:

1. If you desire any change in the protocol or standard recording document at any time, please submit the same to the IEC for information and approval before the change is implemented.
2. As per recommendations of ICMR, you must register your study with the Central Trials Registry-India (CTRI), hosted at the ICMR's National Institute of Medical Statistics (<http://icmr-nims.nic.in>). The registration details as provided by the website are to be submitted to the Institutional Ethics Committee within a period of 3 months from issue of this letter.
3. All serious and/or unexpected adverse events due to the drug/procedures tested in the study must be informed to the IEC within 24 hours and steps for appropriate treatment must be immediately instituted.
4. In case of injury/disability/death of any participant attributable to the drug/procedure under study, all compensation is to be made by the sponsor of the study.
5. The Chief investigator/Researcher must inform the IEC immediately if the study is terminated earlier than planned with the reasons for the same.
6. The final results of the study must be communicated to the IEC within 3 months of the completion of data collection.
7. The researcher must take all precautions to safeguard the rights, safety, dignity and wellbeing of the participants in the study.
8. The researcher must be up to date about all information regarding the risk/benefit ratio of any drug/procedure being used and any new information must be conveyed to the IEC immediately. The IEC reserves the right to change a decision on the project in the light of any new knowledge.
9. Before publishing the results of the study, the researcher must take permission from the Dean of the Institution.
10. Annual progress report should be submitted for all sponsored projects to the committee.
11. Unethical conduct of research in non-sponsored projects will result in withdrawal of the ethics approval and negation of all data collected till that date.

Dr. Mrs. Shrimpa R. Sharma
Member Secretary, IEC
Member Secretary,
Institutional Ethics Committee
D. Y. Patil Medical College,
Kolhapur - 416 006

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SCIENTIFIC RESEARCH COMMITTEE REVIEW MEETING

Please Enter Mandatory Field Only (*)

Date: 26.04.2022

Place: Mumbai

Principal Investigator Name* : Mr. Ratheesh Kanjirath Eddam
Guide Name/ Co-Principal Investigator* : Dr. K. MAYAKANNAN, M. Sc., Ph. D
Co- Guide Name (If Applicable) * : Not Applicable
Research Topic* : Analysis of angular dependencies between OSLD
and TLD- comparison of its in vivo surface dose measurements for post
mastectomy chest wall irradiation

Abstract / Brief Introduction to the topic* :

" Analysis of angular dependencies between OSLD and TLD- comparison of its in-vivo surface dose measurements for post mastectomy breast irradiation". A study on the dose evaluation on Patient undergoing radiotherapy intended to conduct in HCG Cancer Centre towards the accomplishment of PhD. The study involves a placement of dosimeter on the patient (surface, without affecting the treatment outcome). a 100 number of patients proposed to be studied.

Observations/ Recommendations:

1) Which study will be the standard for comparison?	The study from TPS as it will be actually delivered on the Patient. And the OSLD and TLD individually compared to TPS dose
2) Statistician Discussed the justification of Sample size	The General Calculated SS is 80 so selected 100
3) Why MRM patients were selected?	Uniformity is marginally varying in MRM, so it was selected
4) How TLD will be measured?	It will be done at DY Patil University
5) How to find the number of MRM patients as MRM is reducing nowadays?	In case the sample size is not achieved at the centre, then will need to look for collaborations with other centers.
6) Dr Shyam suggested to include BCS studies to increase the literature numbers	PI took note of the same for action

Changes/ Corrections/ Improvements to be made: NIL

Conclusion:

Thesis Approved

Thesis Approved with above recommendations

HCG Cancer Centre

SRC Committee Seal

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NOC for Patient Data Access

TO WHOMSOEVER IT MAY CONCERN

TO,
Principal Investigator
Mr. Ratheesh Kanjirath Eddam

PhD study Titled: Analysis of angular dependencies between OSLD and TLD-comparison of its in vivo surface dose measurements for post mastectomy chest wall irradiation

He has received Ethics Committee Approval from D.Y. Patil Education Society Kohlapur- 416 006 Maharashtra, India. And Scientific Research Committee Approval from HCG Cancer Centre, Borivali, Mumbai. Following the same He shall be granted Access to Patient records and Data only for the purpose of study. The Privacy and Confidentiality of Patient data should be maintained for Good clinical practice. In case you end your association with us, then an undertaking on Data privacy shall be required of you and The Parent organization should be given the credits for Publication.


Dr Anuresh Jain
Medical Superintendent
HCG Cancer Centre, Borivali, Mumbai

For Appointment Please Call : 022-62579999/7406499999

HCG Cancer Centre

Registered Office : HCG Tower, No.8, P. Kalinga Rao Road, Sampangi Rama Nagar, Bangalore - 560027

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HCG – SCIENTIFIC REVIEW COMMITTEE

Date: 26-04-2022

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Dr Anuresh Jain
Head of Institute
HCG Cancer Centre

Member Secretary

Dr Japhia Sajju
Clinical Pharmacologist

Members

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Consultant Radiation
Oncology

Dr Upasna Saxena
Consultant Radiation
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Dr Yash Mathur
Consultant Head & Neck
Surgeon

Dr Suraj Chiranya
Consultant
Haematology & BMT
Physician

Subject Expert

Dr Shyam K Shrivastava
Head of department
Radiation Oncology

Statistician

Ms. Tintu Raj
Biostatistician, Healthcare
Global Enterprises

To
Mr. Ratheesh Kanjirath Eddam
Medical Physicist & RSO
HCG Cancer Centre

SRC Ref No: HCG/SRC/01/2022

Principal Investigator – Mr. Ratheesh Kanjirath Eddam

Study Title: Analysis of angular dependencies between OSLD and
TLD- comparison of its in vivo surface dose measurements for post
mastectomy chest wall irradiation

The Study was discussed in the SRC meeting held on 26.04.2022

It was approved and recommended for the presentation to the
Institutional Ethical Review Board (IERB) with/without following
suggestions.

- Suggestion to include BCS Studies to increase the literature numbers
- In case the sample size is not achieved, then collaborate with other centers

Dr Anuresh Jain
Chairman SRC,
HCG CANCER CENTRE,
BORIVALI, MUMBAI

HCG Cancer Centre

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