

**INVESTIGATION OF TREATMENT PLANNING AND DOSE
VERIFICATION PROCEDURES USING UNFLAT LINAC
PHOTON BEAMS**

**A
THESIS
SUBMITTED TO**



**MAHARAJA RANJIT SINGH
PUNJAB TECHNICAL UNIVERSITY
BATHINDA, PUNJAB (INDIA)**

**IN FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF**

**DOCTOR OF PHILOSOPHY
IN
FACULTY OF SCIENCES**

By

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(OCTOBER 2022)

CANDIDATE'S DECLARATION

I hereby declare that the work which is being presented in the thesis, entitled **“INVESTIGATION OF TREATMENT PLANNING AND DOSE VERIFICATION PROCEDURES USING UNFLAT LINAC PHOTON BEAMS”** in fulfilment of the requirements of the award of the degree of Doctor of Philosophy in Faculty of Sciences and submitted in Department of Physics, Maharaja Ranjit Singh Punjab Technical University, Bathinda, is an authentic record of my own work carried out during a period from August 2016 to October 2022 under the supervision of **Dr. Sandeep Kansal, Professor & Head, Department of Physics, MRSPTU, Bathinda and Dr. Vinod Kumar Dangwal (Co-supervisor), Associate Professor (Medical Physics), Department of Radiotherapy, Government Medical College, Patiala.**

The matter embodied in this thesis has not been submitted by me for the award of any other degree of this or any other University/Institute.

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DEDICATION

**MY DEGREE OF DOCTOR OF
PHILOSOPHY IS DEDICATED TO
MY PARENTS**

ACKNOWLEDGEMENT

I still can't believe my PhD journey has come to an end. During my Ph.D. tenure, I worked with a large number of people who made significant contributions to the research and thesis writing in various ways. I gained important knowledge during this period and a very valuable academic experience. These were possible through the direct or indirect contributions of many people, whom I would like to thank.

I believe that first and foremost I owe a debt of gratitude to my parents for bringing me up to be the person that I am today, for having faith in me, and for allowing me the freedom and space to develop in whatever way I deemed appropriate. You have never wavered in your commitment to offering me assistance in any form. This work, this thesis, is dedicated to both of you, Mammi and Papa. Thank you!

I would like to express my most sincere gratitude to the most important people without whom this was absolutely not possible are my Ph.D. supervisor, Prof. Sandeep Kansal, Department of Physics, MRSPTU, Bathinda and co-supervisor, Dr. Vinod Kumar Dangwal, Associate Prof. (Medical Physics), Department of Radiotherapy, GMC, Patiala for their unwavering support during my Ph.D. study and research, as well as for their patience, motivation, enthusiasm, and vast knowledge. Their guidance helped me during my Ph.D. research work and writing of this thesis. I could not have dreamed of having a better advisor and mentor for my Ph.D. study.

During the time that I was working toward my Ph.D., I was fortunate enough to have the unwavering support of my Ph.D. mates, Dr. Amit Singla, and her wife, Ms. Supriya. I would like to take this opportunity to convey my deepest gratitude to both of them. It would never have been possible for me to take this work to completion without their incredible support and encouragement.

I thank to Prof. Buta Singh Sidhu, Vice-chancellor, MRSPTU, Bathinda for their encouragement and assistance during my research.

It is my privilege to express heartfelt thanks and sincere gratitude to Madam Mamta Kansal, Associate Professor and Head, Department of Mathematics, MRSPTU, Bathinda, for providing her valuable support and teachings during my Ph.D. course work. I am immensely grateful to her.

My sincere thanks also goes to Mr. Rahul Menon, Jr. Tech. (Grade-II), Department of Physics, MRSPTU, Bathinda, and Mr. Jaswinder Singh, Jr. Assist., University Business School, MRSPTU, Bathinda, India for their support during my thesis work.

In addition, I would like to take this opportunity to thank the non-teaching staff of the department for providing administrative and other types of assistance during this time period.

Finally, I would like to extend my warmest regards and gratitude to my parents for their dedication to my ambition, affectionate company, moral support, and selfless personal sacrifices, and to my brother and sisters for being a constant source of motivation that helped me throughout my work. I'm also grateful to all my family members, friends, and well-wishers for all the support they gave me during this period.

Shekhar Dwivedi

LIST OF FIGURES

Figure No.	Title	Page No.
1.1	Stages of tumor development and mechanism of metastasis	2
1.2	External beam radiation therapy	4
1.3	Components of a medical linear accelerator	5
1.4	Schematic diagram of medical linear accelerator	6
1.5	Schematic diagram of three systems for electron beam bending	8
1.6	Schematic diagram of FF and FFF photon beam modes in a medical LINAC	11
1.7	Schematic description of (i) rescaling of FFF beam profile with FF beam as suggested by Pönisch et al. (ii) and penumbra of FFF beam	12
1.8	A schematic illustration of the large and small field scenarios	16
1.9	Schematic presentation of clinical structure definition as per ICRU 50 and ICRU 62.	20
1.10	A schematic representation of (a) forward planning, and (b) inverse planning	23
1.11	A schematic representation of IMRT and VMAT delivery	24
1.12	Examples of arc geometries for one, two, three, or four arc VMAT plans for cranial SRS planning	24
1.13	Steps of radiotherapy treatment planning	26
2.1	TrueBeam Linear Accelerator	33
2.2	Sun nuclear three dimensional (3D) scanner water phantom	34
2.3	SNC125c ionization chamber	35
2.4	PinPoint ionization chamber	35
2.5	Edge detector	36
2.6	Thermoluminescence dosimeter (TLD)-100 chips	37
2.7	GafChromic film	37
2.8	Rando Man Phantom	38
2.9	ArcCHECK diode array	40
2.10	MapCHECK 3 diode array	41
2.11	Electronic portal imaging device based portal dosimetry system	41
3.1	Beam profiles of 6 MV flattening filter-free (FFF) beam measured	51

Figure No.	Title	Page No.
	using different detectors for field size 0.6 cm × 0.6 cm.	
3.2	Beam profiles of 6 MV flattening filter-free (FFF) beam measured using different detectors for field size 1.0 cm × 1.0 cm.	51
3.3	Beam profiles of 6 MV flattening filter-free (FFF) beam measured using different detectors for field size 2.0 cm × 2.0 cm.	52
3.4	Beam profiles of 6 MV flattening filter-free (FFF) beam measured using different detectors for field size 3.0 cm × 3.0 cm.	52
3.5	Beam profiles of 6 MV flattening filter-free (FFF) beam measured using different detectors for field size 4.0 cm × 4.0 cm.	53
3.6	Beam profiles of 6 MV flattening filter-free (FFF) beam measured using different detectors for field size 6.0 cm × 6.0 cm.	53
3.7	Percentage depth doses (PDDs) of 6 MV flattening filter-free (FFF) beam measured using different detectors for field size 0.6cm ×0.6 cm.	54
3.8	Percentage depth doses (PDDs) of 6 MV flattening filter-free (FFF) beam measured using different detectors for field size 1.0cm ×1.0 cm.	54
3.9	Percentage depth doses (PDDs) of 6 MV flattening filter-free (FFF) beam measured using different detectors for field size 2.0cm ×2.0 cm.	55
3.10	Percentage depth doses (PDDs) of 6 MV flattening filter-free (FFF) beam measured using different detectors for field size 3.0cm ×3.0 cm.	55
3.11	Percentage depth doses (PDDs) of 6 MV flattening filter-free (FFF) beam measured using different detectors for field size 4.0cm ×4.0 cm.	56
3.12	Percentage depth doses (PDDs) of 6 MV flattening filter-free (FFF) beam measured using different detectors for field size 6.0cm ×6.0 cm.	56
3.13	Output factor (without corrections) of a 6 MV flattening filter-free (FFF) beam as a function of field size measured using different detectors	59
3.14	Output factor (with corrections) of 6 MV flattening filter-free (FFF) beam as a function of field size measured using different detectors.	59
3.15	Full-width half maxima (FWHM) of 6 MV flattening filter-free (FFF) beam as a function of field size measured using different detectors	61
3.16	Penumbra of 6 MV flattening filter-free (FFF) beam as a function of	62

Figure No.	Title	Page No.
	field size measured using different detectors	
3.17	Degree of unflatness of 6 MV flattening filter-free (FFF) beam as a function of field size measured using different detectors	63
3.18	Symmetry of 6 MV flattening filter-free (FFF) beam as a function of field size measured using different detectors	63
3.19	Surface dose of 6 MV flattening filter-free (FFF) beam as a function of field size measured using different detectors	64
3.20	Depth dose of 6 MV flattening filter-free (FFF) beam as a function of field size measured using different detectors	65
3.21	Depth of maximum dose of 6 MV flattening filter-free (FFF) beam as a function of field size measured using different detectors	65
4.1	Three-dimensional (3D) model view of RANDO phantom; organs and tissues are represented by different colors	75
4.2	Dose distribution of the three different planning techniques for PTV#8 (both central and peripheral) in the axial plane	82
4.3	Mean dose volume histogram (DVH) of the three different planning techniques for central lung PTVs	83
4.4	Mean dose volume histogram (DVH) of the three different planning techniques for peripheral lung PTVs	83
5.1	Dose distribution of the four different beam arrangement VMAT techniques for thoracic PTV#4	98
5.2	Dose distribution of the four different beam arrangement VMAT techniques for lumbar PTV#8	98
5.3	Dose volume histogram (DVH) of the four different beam arrangement VMAT techniques for thoracic PTV#4	99
5.4	Dose volume histogram (DVH) of the four different beam arrangement VMAT techniques for lumbar PTV#8	99
5.5	Gradient index (GI) for the four different beam arrangement VMAT techniques	100
5.6	Conformity index (CI) for the four different beam arrangement	101

Figure No.	Title	Page No.
	VMAT techniques	
5.7	Homogeneity index (HI) for the four different beam arrangement VMAT techniques	101
5.8	Volume of partial cord receiving 10 Gy (V_{10Gy}) for the four different beam arrangement VMAT techniques	102
5.9	Maximum dose to 0.03 cc partial cord for the four different beam arrangement VMAT techniques	103
5.10	Monitor units (MUs) for the four different beam arrangement VMAT techniques	104
6.1	Experimental setup of various pretreatment verification tools (A) MapCHECK 3, (B) Electronic portal imaging device (EPID), and (C) ArcCHECK	113
6.2	Two dimensional (2D) images of the gamma passing rate based on gamma evaluation for various pretreatment verification tools (A) MapCHECK 3, (B) Portal Dosimetry, (C) PerFRACTION, (D) ArcCHECK	114

LIST OF TABLES

Table No.	Title	Page No.
3.1	Characteristics of the different detectors used in this study	47
3.2	Nominal square field sizes and corresponding equivalent square small field sizes for 6 MV flattening filter-free (FFF) beams of Varian TrueBeam linear accelerator	57
3.3	Overall standard uncertainty ($k = 2$, 95% confidence interval [CI]) evaluated for different detectors	60
4.1	The size of the twelve PTVs ($n = 12$) per location (central or peripheral) of the lung used in this study	76
4.2	RTOG dose constraints to OARs	78
4.3	Summary of mean dosimetric indices for the FFF-3DCRT, FFF-IMRT, and FFF-VMAT treatment plans of combined lung PTVs	84
4.4	Summary of mean dosimetric indices for the FFF-3DCRT, FFF-IMRT, and FFF-VMAT treatment plans by different lung locations	85
5.1	The size of the eight PTVs ($n = 8$) per location of the spine (thoracic or lumbar) used in this study	94
5.2	Plan acceptance criteria of tumor and critical organs for single fraction spinal SBRT	95
5.3	Mathematical definition of plan quality metrics studied	96
5.4	Summary of mean dosimetric indices	97
6.1	The mean percentage gamma passing rates of lung VMAT plans using a 10% dose threshold for four different pretreatment QA tools	115
6.2	The mean percentage gamma passing rates of spinal VMAT plans using a 10% dose threshold for four different pretreatment QA tools	116
6.3	The mean percentage gamma passing rates of combined VMAT plans using a 10% dose threshold for four different pretreatment QA tools	117
6.4	The mean percentage gamma passing rates of lung VMAT plans using a 5% dose threshold for four different pretreatment QA tools	118

Table No.	Title	Page No.
6.5	The mean percentage gamma passing rates of spinal VMAT plans using a 5% dose threshold for four different pretreatment QA tools	119
6.6	The mean percentage gamma passing rates of combined VMAT plans using a 5% dose threshold for four different pretreatment QA tools	120
6.7	Statistical comparison of the global gamma passing rates among four pretreatment QA tools	121
6.8	Statistical comparison of the local gamma passing rates among four pretreatment QA tools	122

PREFACE

In the present study, small field dosimetry, stereotactic body radiotherapy (SBRT) treatment planning, and dose verification procedures for a 6 MV FFF beam have been investigated. The thesis is divided into six chapters.

CHAPTER 1: INTRODUCTION

This chapter provides an overview of cancer, radiotherapy, linear accelerators, flattening filter (FF) and flattening filter-free (FFF) photon beams, small field dosimetry and detectors, radiotherapy planning, treatment planning system, and patient-specific quality assurance (QA). It includes a detailed literature review on FFF photon beams, treatment planning, and pretreatment QA, as well as the objectives of the current investigation.

CHAPTER 2: INSTRUMENTATION

This chapter focuses on the specific instruments and devices, such as linear accelerator, radiation field analyzer, various radiation detectors, phantoms, treatment planning system, and pretreatment verification devices that were utilised to achieve the defined research objectives.

CHAPTER 3: DOSIMETRY OF A 6 MV FFF SMALL BEAM USING VARIOUS DETECTORS

This chapter deals with the measurement of small fields using ionization chambers, thermoluminescent dosimeters (TLDs), diode detectors, and radiochromic films. The 6 MV flattening filter-free (FFF) photon beam was used for measurement of output factor, depth dose, and beam profile of small-fields of sizes $0.6\text{ cm} \times 0.6\text{ cm}$ to $6.0\text{ cm} \times 6.0\text{ cm}$. All measurements were performed as per the International Atomic Energy Agency TRS 483 protocol.

CHAPTER 4: DOSIMETRIC COMPARISON OF DIFFERENT PLANNING TECHNIQUES BASED ON FFF BEAM FOR LUNG SBRT

In this chapter, the dosimetric comparison and evaluation of flattening filter-free (FFF) photon beam-based three-dimensional conformal radiotherapy (3DCRT), intensity-modulated radiation therapy (IMRT), and volumetric modulated arc therapy (VMAT) for lung stereotactic body radiotherapy (SBRT) have been discussed.

CHAPTER 5: DOSIMETRIC COMPARISON OF THE MONO- AND DUAL-ISOCENTRIC VMAT TECHNIQUE FOR SPINAL SBRT

This chapter evaluates the planning characteristics of spinal stereotactic body radiotherapy (SBRT) using mono- and dual-isocentric volumetrically modulated arc therapy (VMAT) techniques. The dosimetric indices were compared between different beam arrangement techniques for spinal SBRT planning, including spinal cord avoidance, planning target volume (PTV) dose coverage, conformity, homogeneity, and gradient index.

CHAPTER 6: DOSIMETRIC EVALUATION OF FOUR PRETREATMENT VERIFICATION DEVICES FOR LUNG AND SPINAL SBRT

This chapter compares the four different pretreatment verification tools (MapCHECK 3, ArcCHECK, Portal Dosimetry, and PerFRACTION) for stereotactic body radiotherapy (SBRT) plans. These SBRT plans were generated on an anthropomorphic RANDO man phantom using volumetric modulated arc therapy (VMAT) techniques and a 6-MV flattening filter free (FFF) photon beam.

Finally, the conclusion and scope of future work have been discussed.