

Comparing Volumetric Modulated Arc Therapy to Intensity
Modulated Radiation Therapy for the Treatment of Early
Stage Prostate Cancer

By

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Statement of Originality:

The thesis contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. I give consent to the final version of my thesis being made available worldwide when deposited in the University's Digital Repository, subject to the provisions of the Copyright Act 1968.

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Declaration:

I hereby certify that this thesis is in the form of a series of published papers of which I am the primary author. I have included as part of the thesis a written statement from each co-author, endorsed by the Faculty Assistant Dean (Research Training), attesting to my contribution to the joint publications.

Craig Elith

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List of Abbreviated Terms:

1A	Volumetric Modulated Arc Therapy Using One Arc
1A+PA	Volumetric Modulated Arc Therapy Using One Arc Plus a Partial Arc
2A	Volumetric Modulated Arc Therapy Using Two Arcs
2D	Two Dimensional
3D	Three Dimensional
3DCRT	Three Dimensional Conformal Radiation Therapy
AAA	Anisotropic Analytical Algorithm
BC	British Columbia
BCCA	British Columbia Cancer Agency
Bladder _{opti}	Optimization Structures for the bladder
CAMRT	Canadian Association of Medical Radiation Technologists
CCW	Counter Clockwise
CW	Clockwise
CN	Conformity Number
CT	Computed Tomography
CTCAE	Common Terminology Criteria for Adverse Events
CTV	Clinical Target Volume
D _n	The Dose Covering <i>n</i> % of the Target Volume
DVH	Dose Volume Histogram
DRE	Digital Rectal Examination
DNA	Deoxyribonucleic Acid
EBRT	External Beam Radiation Therapy
EMR	Electronic Medical Record
ERSPC	European Randomised Study of Screening for Prostate Cancer
FVC	Fraser Valley Centre
Fx	Fraction
CAMRT	Canadian Association of Medical Radiation Technologists
Gy	Gray
HI	Homogeneity Index
IGRT	Image Guided Radiation Therapy
IMAT	Intensity Modulated Arc Therapy
IMRT	Intensity Modulated Radiation Therapy
LHRH	Luteinising Hormone Releasing Hormone
Linac	Linear Accelerator
min	Minutes
MLC	Multi-Leaf Collimators
MRI	Magnetic Resonance Imaging

MRT	Medical Radiation Technologists
MUs	Monitor Units
NCI	National Cancer Institute
OAR	Organs at Risk
OR	Odds Ratio
PA	Volumetric Modulated Arc Therapy Using a Partial Arc
PBC	Pencil Beam Convolution
PET	Positron Emission Tomography
PLCO	Prostate, Lung, Colorectal, and Ovarian Cancer
PSA	Prostate Specific Antigen
PTV	Planning Target Volume
PTV _{opti}	Optimization Structures for the PTV
PRO	Progressive Resolution Optimiser Algorithm
QA	Quality Assurance
QoL	Quality of Life
Rectum _{opti}	Optimization Structures for the Rectum
RT	Radiation Therapy
SBRT	Stereotactic Body Radiation Therapy
SIB	Simultaneous Integrated Boost
SSD	Source to Skin Distance
TPS	Treatment Planning System
TV	Target Volume
v8.6	Version 8.6
v10.0	Version 10.0
V_n	Percentage Volume (V) of an Organ Receiving n Dose
V_{Pres}	The Total Volume Receiving the Prescription
V_{TPres}	The Target Volume Covered by the Prescription
VMAT	Volumetric Modulated Arc Therapy
VMAT-1A	Volumetric Modulated Arc Therapy Using One Arc
VMAT-1A+PA	Volumetric Modulated Arc Therapy Using One Arc Plus a Partial Arc
VMAT-2A	Volumetric Modulated Arc Therapy Using Two Arcs
VMAT-PA	Volumetric Modulated Arc Therapy Using a Partial Arc

Abstract:

A series of five studies are presented that when pieced together describe the transition from an innovative concept through to the clinical implementation of the radiation therapy treatment technique, Volumetric Modulated Arc Therapy (VMAT) for the treatment of early stage prostate cancer.

At the outset of the research, Intensity Modulated Radiation Therapy (IMRT) was the standard modality for the treatment of early stage prostate cancer at Fraser Valley Centre (FVC). The initial studies of this research retrospectively compared IMRT to the innovative VMAT technique, specifically examining the quality of the plans produced and the impact of each technique on the departments planning and treatment resources. It was demonstrated that VMAT offered a treatment plan of similar quality to the IMRT technique yet VMAT had the definite advantage of being able to deliver treatment in significantly less time and also required significantly fewer monitor units to deliver a treatment fraction.

Having demonstrated an advantage of using VMAT, it was next investigated which VMAT beam arrangement would be best suited for the treatment of early stage prostate cancer. Four VMAT beam arrangements were considered; and ultimately it was decided that for FVC VMAT using one arc provided the best compromise between plan quality and delivery efficiency.

The increased complexity of VMAT planning and treatment dictates that patient specific quality assurance (QA) is required to ensure accurate dose delivery. A section of this thesis is dedicated to considering VMAT plan QA.

The final study presented here compares the acute side effects experienced by patients being treated with either IMRT or VMAT. VMAT has not only been demonstrated to be a safe alternative to IMRT for the treatment of early stage prostate cancer, in a world first VMAT has also been demonstrated to significantly reduce the incidence of the acute toxicities dermatitis, fatigue, pain and urinary frequency during treatment compared to IMRT.