Hypofractionated Prostate Treatments: Dose, Motion Monitoring and Credentialling

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Declaration

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.

(Signed)________________________________

Kimberley Legge

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Abstract

Hypofractionated and stereotactic radiation therapy techniques are becoming increasingly common for the treatment of prostate cancer. The increased dose per fraction and high dose conformity used in these techniques warrants increased care to ensure accurate and safe dose delivery.

The PROstate Multicentre External beam radioTHErapy Using Stereotactic boost (PROMETHEUS) clinical trial commenced in Australia in November 2014. Prostate cancer patients enrolled in this trial received two hypofractionated “boost” fractions of external beam radiation therapy, each consisting of 9.5-10 Gy and delivered using a volumetric modulated arc therapy (VMAT) technique. Following this, patients received 46 Gy in 2 Gy fractions. Patients treated under this protocol at Calvary Mater Newcastle had a Rectafix rectal displacement device (RDD) in position during the boost fractions, allowing for safer dose escalation with reduced likelihood of rectal wall injury.

The Stereotactic Prostate Adaptive Radiotherapy utilising Kilovoltage intrafraction monitoring (SPARK) trial commenced in February 2016. Patients enrolled in SPARK received hypofractionated, stereotactic prostate radiation therapy prescribed at 36.25 Gy to 95% of the planning target volume (PTV) delivered in 5 fractions. No RDD was in position and prostate position was continually monitored during treatment through the use of Kilovoltage Intrafraction Monitoring (KIM). Patient position is adjusted when prostate displacement exceeds a pre-determined limit for a certain period of time.

This thesis is divided into four parts. The first part presents work on *in vivo* monitoring of the dose to the anterior rectal wall during boost fractions using MO*Skin*s, a type of MOSFET detector not previously used for in-patient measurements during external beam radiation therapy treatments. The MO*Skin*s were attached to the Rectafix and the dose delivered was read out in real time during treatment. The measured dose was compared with the planned dose across the entire treatment delivery, and was found to provide a feasible method of dose verification and dose monitoring during external beam treatments.

Limited literature exists on intrafraction motion in the presence of an RDD. For this reason, intrafraction prostate motion measurements were taken during the PROMETHEUS boost fractions. Motion was measured using the KIM technique, which

calculates the 3D position of the prostate based on segmentation of fiducial markers in 2D kilovoltage images taken continuously during treatment delivery. Considerably less motion was observed in this patient cohort when compared to previous studies of patients without an RDD in place.

The use of kilovoltage imaging to monitor motion during treatment delivers an additional imaging dose to patients. This imaging dose should be quantified to ensure it remains at a safe level. The third part of this thesis describes a simple method for measurement of the imaging dose delivered during SPARK treatments. The method requires minimal equipment and enables consistent measurements to be taken at different radiation therapy centres. The results of measurements taken at all four centres participating in SPARK and on seven different linear accelerators are presented in this chapter, with all machines measuring an imaging dose within 20% of each other.

The reliability of multi-centre clinical trial results can be increased if all centres participate in a credentialling process, particularly when the trial involves the delivery of complex treatment techniques, such as VMAT. Traditional credentialling processes are time consuming and expensive, as they often involve sending staff and/or equipment to remote centres. The final section of this thesis details a pilot study for a novel EPID-based technique for the remote verification of the delivery of VMAT plans. The method is entirely remote, with all data transferred between remote centres and the central site via cloud storage. Six centres had VMAT deliveries successfully verified using this method, which is cost effective, fast and efficient.

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