University of Victoria | Graduate Studies

Notice of the Final Oral Examination
for the Degree of Doctor of Philosophy

of

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MSc (San Diego State University, 2013)
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"Microcomputed Tomography Dosimetry and Image Quality in Preclinical Image-Guided Radiation Therapy"

Department of Physics and Astronomy

Friday, April 5, 2019
10:00 A.M.
Clearihue Building
Room B017

Supervisory Committee:
Dr. Magdalena Bazalova-Carter, Department of Physics and Astronomy, University of Victoria (Supervisor)
Dr. Derek Wells, Department of Physics and Astronomy, UVic (Member)
Dr. Julian Lum, Department of Biochemistry and Microbiology, UVic (Outside Member)

External Examiner:
Dr. Eric Ford, Radiation Oncology, University of Washington

Chair of Oral Examination:
Dr. David Berg, Department of Chemistry, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

Motivated by the need to standardize preclinical imaging for image-guided radiation therapy (IGRT), we examine the parameters that influence microcomputed tomography (microCT) scans in the realm of image quality and absorbed dose to tissue, including therapy beam measurements of small fields.

Preclinical radiation research aims to understand radiation-induced effects in living tissues to improve quality of life. Small targets and low kilovoltage x-rays create challenges that do not arise in clinical radiation therapy.

Evidence based on our multi-institutional study reveals a considerable aberration in microCT image quality from one institution to the next. We propose the adoption of recommended tolerance levels to provide a baseline for producing satisfactory and reproducible microCT image quality scans for accurate dose delivery in preclinical IGRT.

Absorbed dose imparted by these microCT images may produce deterministic effects that can negatively influence a radiobiological study. Through Monte Carlo (MC) methods we establish absorbed microCT imaging dose to a variety of tissues and murine sizes for a comprehensive combination of imaging parameters. Radiation beam quality in the small confines of a preclinical irradiator is also established to quantify the effects of beam scatter on half-value layer measurements.

MicroCT scans of varying imaging protocols are also compared for murine subjects. Absorbed imaging dose to tissues are established and presented alongside their respective microCT images, providing a visual bridge to systematically link image quality and imaging dose.

We then characterize a novel small plastic scintillating dosimeter to experimentally measure microCT imaging and therapy beams. The presented scintillating dosimeter is specifically characterized for the low energies and small fields found in preclinical research. Beam output is measured in real-time for small fields previously only achievable using film. Finally, quality assurance tests are recommended for a preclinical IGRT unit.

Within this dissertation, a narrative is presented for guiding preclinical radiotherapy towards producing high quality microCT images with an understanding of the absorbed imaging dose deposited to tissues, including providing a tool to measure small radiation fields.