University of Victoria | Graduate Studies

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

of

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MSc (University of Victoria, 2014)
BSc (University of Victoria, 2010)

"Applications of X-ray Computed Tomography Polymer Gel Dosimetry"

Department of Physics and Astronomy

Thursday, December 6, 2018
2:30 P.M.
Clearihue Building
Room B017

Supervisory Committee:
Dr. Andrew Jirasek, Department of Physics and Astronomy, University of Victoria (Co-Supervisor)
Dr. Michelle Hilts, Department of Physics and Astronomy, UVic (Co-Supervisor)
Dr. Derek Wells, Department of Physics and Astronomy, UVic (Member)
Dr. Jody Klymak, School of Earth and Ocean Sciences, UVic (Outside Member)

External Examiner:
Dr. Yves De Deene, Department of Engineering, Macquarie University

Chair of Oral Examination:
Dr. Wanda Boyer, Department of Education Psychology & Leadership Studies, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

Radiation therapy, one of the most common forms of cancer treatment, is continually evolving with the introduction of new technology, more complex treatments and more advanced radiation dose calculations. To ensure the effectiveness and safety of modern radiation therapy, dose measurement tools must improve to accommodate these advances. X-ray computed tomography (CT) polymer gel dosimetry is a unique type of dosimeter that has many advantages and the potential to address some of the challenges in the verification of dose delivery and calculation in radiation therapy. This dissertation investigates the advancement of an x-ray CT polymer gel dosimetry system for use in clinical applications and in particular for deformable dose verification.

The first part of this work consists of a reproducibility study of an established x-ray CT polymer gel dosimetry system in an effort to determine the accuracy and precision of dose measurements made with this system and the feasibility of interbatch and generic calibration. Gel measurements were found to have excellent agreement with Monte Carlo dose calculation when using a generic calibration curve. The excellent dosimetric and spatial accuracy established in this study suggest that this dosimetry system is ideally suited for the measurement of high-dose fractionation treatments such as stereotactic radiosurgery (SRS) or stereotactic body radiation therapy (SBRT). The second stage was the development and characterization of the first deformable x-ray CT polymer gel dosimetry system. This study established the setup reproducibility, deformation characteristics and dose response of the new deformable system. The dose response was found to be similar to that of the nondeformable system with similar dosimetric and spatial accuracy when compared to Monte Carlo dose calculation. The system was also found to have sub-millimetre setup reproducibility and the deformable dosimeter was found to reproducibly deform and relax for external compression of up to 30 mm and over 100 consecutive compressions. This work established several important characteristics of the new deformable dosimetry system and it shows excellent potential for use in the evaluation of deformable dose accumulation algorithms.

The final component of this dissertation was the use of the newly developed deformable dosimetry system in the evaluation of a novel deformable dose accumulation algorithm, defDOSXYZ. Gel measurements and defDOSXYZ showed excellent agreement in the case of

a static control case and this set a benchmark for deformable dose measurements. Measurements of deformed dose by the gel dosimeter showed significant disagreement with dose deformed by defDOSXYZ and the dosimetric differences were well outside the uncertainties established in the first two studies of this dissertation. The results from this study provided some insight into potential avenues of improvement for both the deformable dose calculation and deformable dose measurements. These results were also the first example of deforming dose measured by an x-ray CT read out gel dosimetry system.

Overall, the results in this dissertation represent a significant advancement in x-ray CT polymer gel dosimetry and establish its suitability for several clinical applications.