Research Statement Peter Watson

Brachytherapy is a form of cancer therapy whereby a radiation source is placed in close proximity to cancerous tissue. Historically, brachytherapy has been performed with radioactive nuclides, however there has been development in the use of miniature electronic x-ray sources, dubbed “electronic brachytherapy”. The aim of this project is to improve the accuracy of radiation dose measurement (dosimetry) of electronic brachytherapy sources. In particular, we wish to evaluate and improve upon the current dosimetry protocol of one such miniature x-ray source, the INTRABEAM System (Carl Zeiss, Germany).

To validate the manufacturer's dose calculation method, we have proposed a new absorbed dose to water formalism using an ionization chamber calibrated in terms of air-kerma. First, a monte carlo (MC) model of the INTRABEAM source was developed and validated against measurements of half-value layer in-air using the EGSnrc particle transport code [1]. Using this model, a conversion factor was derived to convert the ionization chamber calibration coefficient to absorbed dose to water for the INTRABEAM photon spectrum. Our results suggest that the manufacturer's calculation underestimates the dose by up to 20% [2]. As an independent verification, we plan to make measurements using another dosimeter technology, that of EBT-3 Gafchromic film. In the final stage of the project, the feasibility of performing a dose measurement using a water calorimeter with the INTRABEAM will be investigated. The time-dependent temperature gradients generated from absorbed dose and source self-heating will be modelled using a finite-element solver (COMSOL). These results will determine whether a calorimetric measurement of INTRABEAM is possible with current technology.

Improving the dosimetry of electronic brachytherapy sources will allow for their use in conjunction with external beam radiotherapy, and will help to expand their use to other cancer sites in the body. Most importantly, reducing the uncertainty of delivered dose will ultimately lead to improving the quality of patient care.

[1] Watson, P.G.F. and Seuntjens J. *A monte carlo model of a miniature low-energy x-ray tube using EGSnrc.* Med. Phys. **41**, 24 (2014).
[2] Watson, P.G.F. and Seuntjens, J. *Investigation of an absorbed dose to water formalism for a miniature low-energy x-ray source.* COMP Annual Scientific Meeting (2016) (accepted).