PhD Thesis Title: Novel brachytherapy techniques for cervical cancer and prostate cancer

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ABSTRACT:

Intensity-modulated brachytherapy techniques, compensator-based intensity modulated brachytherapy (CBT) and interstitial rotating shield brachytherapy (I-RSBT), are two novel conceptual radiation therapies for treating cervical and prostate cancer, respectively. Compared to conventional brachytherapy techniques for treating cervical cancer, CBT can potentially improve the dose conformity to the high-risk clinical target volume (CTV) of the cervix in a less invasive approach. I-RSBT can reduce the dose delivered to the organs at risk (OARs) while maximizing dose to the prostate CTV. In this work, concepts and prototypes for CBT and I-RSBT are introduced and developed. Preliminary dosimetric measurements were performed for CBT and I-RSBT, respectively.

A CBT prototype system was constructed and experimentally validated. A prototype cylindrical compensator with eight octants, each with different thicknesses, was designed. Direct metal laser sintering (DMLS) was used to construct CoCr and Ti compensator prototypes, and a 4-D milling technique was used to construct a Ti compensator prototype. Gafchromic EBT2 films, held by an acrylic quality assurance (QA) phantom, were irradiated to approximately 125 cGy with an electronic brachytherapy (eBT) source for both shielded and unshielded cases. The dose at each point on the films were calculated using a TG-43 dose calculation formalism that was modified to account for the presence of a compensator prototype by ray-tracing.

With I-RSBT, a multi-pass dose delivery mechanism with various prototypes was developed. Dosimetric measurements for a Gd-153 radioisotope was performed to demonstrate that using multiple partially shielded Gd-153 sources for I-RSBT is feasible. A treatment planning model was developed for applying I-RSBT clinically. A custom-built, stainless steel encapsulated 150 mCi Gd-153 capsule with an outer length of 12.8 mm, outer diameter of 2.10 mm, active length of 9.98 mm, and active diameter of 1.53 mm was used. A partially shielded catheter was constructed with a 500 µm platinum shield and a 500 µm aluminum emission window, both with 180° azimuthal coverage. An acrylic phantom was constructed to measure the dose distributions from the shielded catheter in the transverse plane using Gafchromic EBT3 films. Film calibration curves were generated from 50, 70, and 100 kVp X-ray beams with NIST-traceable air kerma values to account for energy variation.

In conclusion, CBT, which is a non-invasive alternative to supplementary needles in interstitial brachytherapy, is expected to improve dose conformity to bulky cervical tumors relative to conventional intracavitary brachytherapy. However, at the current stage, it would be time-consuming to construct a patient-specific compensator using DMLS, and the quality assurance of the compensator would be difficult. I-RSBT is a promising approach to reducing radiation dose delivered to OARs in prostate cancer. Next step in making Gd-153 based I-RSBT feasible in clinic would

be to develop a Gd-153 source that is small enough such that the source, shield, and catheter all fit within a 16 guage needle, which has a 1.65 mm diameter.

References to author publications that relate specifically to the dissertation:

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