Improving Dose Determination Accuracy in Nonstandard Fields of the Varian TrueBeam Accelerator

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In recent years, the use of flattening-filter-free (FFF) linear accelerators in radiation-based cancer therapy has gained popularity, especially for hypofractionated treatments (high doses of radiation given in few sessions). However, significant challenges to accurate radiation dose determination remain. If physicists cannot accurately determine radiation dose in a clinical setting, cancer patients treated with these new machines will not receive safe, accurate and effective treatment. In this study, an extensive characterization of two commonly used clinical radiation detectors (ionization chambers and diodes) and several potential reference detectors (thermoluminescent dosimeters, plastic scintillation detectors, and alanine pellets) has been performed to investigate their use in these challenging, nonstandard fields. From this characterization, reference detectors were identified for multiple beam sizes, and correction factors were determined to improve dosimetric accuracy for ionization chambers and diodes. A validated computational (Monte Carlo) model of the TrueBeam™ accelerator, including FFF beam modes, was also used to calculate these correction factors, which compared favorably to measured results. Small-field corrections of up to 18 % were shown to be necessary for clinical detectors such as microionization chambers. Because the impact of these large effects on treatment delivery is not well known, a treatment planning study was completed using actual hypofractionated brain, spine, and lung treatments that were delivered at the UW Carbone Cancer Center. This study demonstrated that improperly applying these detector correction factors can have a substantial impact on patient treatments. This thesis work has taken important steps toward improving the accuracy of FFF dosimetry through rigorous experimentally and Monte-Carlo-determined correction factors, the validation of an important published protocol (TG-51) for use with FFF reference fields, and a demonstration of the clinical significance of small-field correction factors. These results will facilitate the safe, accurate and effective use of this treatment modality in the clinic.