Uncertainty analysis of radiochromic film dosimetry at orthovoltage energy - TG-51 vs TG-61 approach

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Abstract: EBT3 radiochromic film offers a dosimetry technique that is very flexible in cell and small animal irradiation conditions. Most researchers calibrate EBT3 film with the same orthovoltage irradiator. The delivered dose of the orthovoltage irradiator was determined following AAPM TG-61. However, the uncertainties from TG-61 calibration for dose at the surface is 3.6%. Combining with the uncertainty from film dosimetry, the overall uncertainty obtained from EBT3 film would be much greater. The objective of this work was to evaluate the overall impact of the uncertainties in EBT3 film dosimetry using TG-61. In addition, an alternative method of EBT3 calibration at kV energies by combining the MV calibration (TG51) and published energy correction factors is explored. A Precision XRAD-225 was calibrated with an ionization chamber following TG61. EBT3 films were irradiated under full back scatter condition on top of solid water blocks to establish a calibration curve (*TG61*). Films were also irradiated under a 6MV linear accelerator to establish a separate calibration curve (*TG51*). Energy responses of the film were determined from Hammer 2018, together with the uncertainty value. Film uncertainties were characterized by a series of irradiation and scanning experiments. The total dose uncertainties from each method were derived through uncertainty propagation. Film calibration through TG61 was determined to have an associated total uncertainty of 5.2% and film calibration through TG51 followed by the application of Hammer (2018) energy correction factor was determined to have an associated total uncertainty of 3.7%. For absolute dose determination, there is 1% difference between these two methods, well within the dosimetric uncertainty for each method. This work recommends the use of film calibrated with a MV accelerator as this method has the lowest associated uncertainty.