

A study on the determination of relative output factors for very small fields in stereotactic radiosurgery

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INTRODUCTION

Small field dosimetry provides many challenges which are still being resolved so that radiotherapy services can have accurate radiation dosimetry. For small radiation fields, there are various physical conditions that occur including a lack of lateral charged particle equilibrium on the beam axis, the size of the detector is comparable or larger than the field size and there is partial occlusion of the primary photon source by the collimators and differences in the radiological water equivalence of the water. The IAEA TRS-483 Code of Practice (COP) provides advice on how to measure small field dosimetry data as well as correction factors for commonly used detectors for a range of field sizes and beam energies. However the COP does not include data for recently released detectors such as the IBA Razor diode and there is minimal data for very small fields with dimensions less than 5 mm. This provides a challenge for clinical radiation oncology departments which have a stereotactic radiosurgery (SRS) program using cones with beam diameters down to 4 mm as defined at the isocentre. The purpose of this work was to determine relative output factors (ROFs) for SRS cone defined fields and determine correction factors for the IBA Razor diode using the TRS-483 COP framework.

METHODS

All of the radiation dose measurements were performed on Varian TrueBeam STx for 6X-WFF and 6X-FFF with SRS cone sizes ranging from 4 to 17.5 mm diameter. The detectors used were the IBA Razor diode, IBA Razor ionization chambers and Gafchromic EBT3 film. The Razor diode is p-type unshielded silicon diode which was introduced by IBA as a replacement for their earlier model being the IBA SFD diode. Both of the IBA diodes are customized for measurements in small radiation fields, having an active area of 0.6 mm in diameter with a chip size of 0.95/0.4 mm (side/thickness). For comparison, the Gafchromic EBT3 film was taken as the reference dosimeter. The EBT3 film were scanned using an Epson Scanner XL11000 with 1200 dpi resolution 24 hours after exposure to radiation to allow the film to completely develop. Gafchromic EBT3 film is nearly energy-independent, has almost radiological water-equivalence, gives high spatial resolution and has been shown not to need any corrections for small field dosimetry provided a suitable methodology for the film is applied. All measurements were performed in an IBA Blue Phantom2 scanning water tank at a 5 cm depth with a source-to-surface distance of 95 cm. This geometry was selected to be consistent with the geometry of the radiotherapy treatment planning system. All ROFs were normalized to a 5 × 5 cm² field for both 6X-WFF and 6X-FFF beams and k correction factors for the IBA Razor diode were determined using the TRS-483 COP.

RESULTS

A plot of the ROFs for the 6X-FFF beams is shown in figure 1 along with comparisons with other published data. There was good agreement between our measurements of the ROFs with the IBA Razor diode as compared to data provided by Cheng et al which was measured with the earlier IBA SFD. There was a maximum difference of about 1.5% for the 4 mm diameter cone. However, there are larger differences between the ROFs measured with the Razor diode in comparison to the representative data provided by Varian. The maximum difference is 4.7% for the 5 mm diameter cone and 2.6% for the 7.5 mm diameter cone for 6X-WFF and 6X-FFF beams respectively. The comparison with Peyton Irmen et al for 6X-WFF beam showed generally a good agreement most of the SRS cones sizes with less than 1% difference. However, there were differences of up to 5.8% for the smallest cone and 2.5% for the largest cone. A similar pattern was found for the 6X-FFF beam where there was a maximum difference of 5% for the smallest cone.

CONCLUSIONS

This work has demonstrated that the IBA Razor diode is suitable for the dosimetry of very small radiation fields as found in SRS and consistent in response to the earlier IBA SFD. There is however the need for additional work to determine suitable correction factors for this detector within the methodology of the TRS-483 COP in order to provide accurate radiation dosimetry.

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