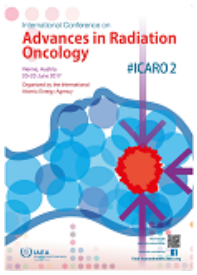

Contribution ID: **94** Type: **Poster**

Accuracy in clinical small field data

Thursday, 22 June 2017 15:45 (5 minutes)

Introduction

Developments in radiotherapy have contributed to an increase in the use of small fields. Small fields are used in stereotactic treatments and large uniform or non-uniform fields that are composed of small fields such as for intensity modulated radiation therapy (IMRT). There has been an increasing availability in the clinic of standard, mini and micro-multileaf collimators on conventional accelerators as well as the introduction of treatment units specifically designed for stereotaxy (GammaKnife, CyberKnife, Radiosurgery System) or intensity modulated treatments (TomoTherapy). There is therefore an increasing demand to characterize small fields in dosimetry more accurately.

There is currently no published international Code of Practice (CoP) for small field dosimetry. There are guidance publications for absolute and non-reference dosimetry measurements e.g. IPEM 103. However, some clinics have been using extrapolated data from CoPs that were published to perform absolute dosimetry in much larger reference field sizes, typically 10 cm x 10 cm e.g. IAEA TRS 398.

In this study, we considered the accuracy with which clinical small field data could be obtained.

Methodology

Measurements were performed using an automated beam scanning system in linear accelerator and Co-60 beams. Different detectors were used to obtain the data and the results were compared. The manufacturer' s engineering diagram was used to position the detectors at their reference point of measurement. Profiles of a range of small fields were measured in the in- and cross-plane directions to obtain the Full Width Half Maximum (FWHM) and to determine the exact position of the Central Axis (CAX) of the beam. A Farmer-type reference instrument, was used to cross-calibrate detectors in a 6 cm x 6 cm field size. Relative dose measurements were also obtained for the different detectors to determine the output factors. All the detectors that were used were waterproof.

The machines used were an MDS Nordion Equinox Co-60 unit and two Siemens Primus linear accelerators operated at 6 MV. The Co-60 unit was equipped with four standard independent jaws and is capable of a 1 cm x 1 cm smallest set field size. One accelerator was equipped with two standard independent collimators in one direction and an 82-leaf multileaf collimator (MLC) in the other.

The detectors used were:
• Synthetic single crystal micro-diamond with a sensitive volume of 0.004 mm^3,
• Unshielded disk-shaped silicon diode detector with sensitive volume of 0.03 mm^3,
• 3-Dimensional cylindrical ion chamber with a vented sensitive volume of 0.016 cm^3,
• Semiflex Ionization Chambers with a vented sensitive volume of 0.125 cm3 and 0.07 cm3,
• Farmer type ionisation chamber, with a vented sensitive volume of 0.6 cm3.
The data obtained from each detector was compared with its associated uncertainties.

Results

The engineering diagrams for detectors and the mechanical machine settings are not adequate to determine CAX within acceptable uncertainties. It is crucial that beams are scanned using a motorised water phantom to determine the FWHM and calculate the CAX from that data during each measurement set up for each detector.

The collimator settings contribute highly to the accuracy of measurements. A good understanding of the MLC design and limitations in the calibration methodology is crucial in order to determine the correct CAX.

There were challenges with positioning detectors in solid phantoms, particularly in a parallel orientation. The ability to precisely position and verify the detector position at its reference point was not possible using film or electronic portal imaging.

Each correction factor contributes to the overall uncertainty of measurements performed using that detector. The more correction factors and the higher the value, the higher the risk of decreased accuracy in the measurements performed using that detector.

Conclusion

The accuracy of the clinical beam data is both dependent on the equipment used and vigilance during measurements. It is crucial that those adopting to use small field dosimetry select and characterise their detectors before they use them for clinical dosimetry. The design of the machine and whether the planning system to be used with that machine will be able to support the small field treatment techniques must be established before commissioning. It is critical that medical physicists are trained to understand the nuances of small field dosimetry and that data are validated through audit programmes before patients are treated. Accurate dosimetry in a solid phantom depends on the ability to visualise and verify the positioning of the chamber in the phantom in addition to the accurate mechanical set up of the machine.

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Session Classification: Thursday afternoon - Poster Presentations - Screen2

Track Classification: Dosimetry