Conclusions: Delivering SBRT with multiple non-coplanar dynamic arcs on Cyberknife is expected to give similar plan quality to the current method of non-coplanar S&S delivery but a delivery time of around half that of S&S delivery. The additional dosimetric uncertainty associated with dynamic delivery is estimated to be better than 1-2%. We are grateful to Accuray Inc. for funding this work.

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A PHASE SPACE MODEL OF A VERSA HD LINEAR ACCELERATOR FOR APPLICATION TO MONTE CARLO DOSE CALCULATION IN A REAL-TIME ADAPTIVE WORKFLOW

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Purpose: Recent developments in intrafraction imaging offer scope for treatment plans to be updated and recalculated in real time so as to follow the observed anatomical changes. This study therefore aims to develop and validate a simple geometric model of the accelerator head, from which a particle phase space can be calculated for application to fast Monte Carlo dose calculation. The particular objective of this study is to investigate whether the phase space model can facilitate dose calculations which are compatible with those of a commercial treatment planning system, for convenient interoperability.

Material and methods: A dual-source model of the head of a Versa HD accelerator (Elekta AB, Stockholm, Sweden) was created. The model consisted of rays traced through the collimators and multileaf collimator to produce a grid of divergent photons. For each discrete source, the array of photons was convolved with a Gaussian function to model the finite size of the source. The model used parameters chosen to be compatible with those of 6-MV flattened and 6-MV flattening filter-free beams in the RayStation treatment planning system (RaySearch Laboratories, Stockholm, Sweden). The phase space model was used to calculate a photon phase space for several treatment plans and the resulting phase space was applied to the Dose Planning Method (DPM) Monte Carlo dose calculation algorithm. Simple fields and intensity-modulated radiation therapy (IMRT) treatment plans for prostate and lung were calculated for benchmarking purposes and compared with the convolution-superposition dose calculation within RayStation.

Results: For simple square fields in a water phantom, the calculated dose distribution agrees to within ±2% with that from the commercial treatment planning system, except in the buildup region, where the DPM code does not model the electron contamination. For IMRT plans of prostate and lung, agreements of ±2% and ±6% respectively are found, with slightly larger differences in the high dose gradients. For the IMRT plans, calculation time is of the order of 3 minutes on a 4-core processor using 8 threads.

Conclusions: The phase space model presented allows convenient calculation of a phase space for application to Monte Carlo dose calculation, with straightforward translation of beam parameters from the RayStation beam model. This provides a basis on which to develop dose calculation in a real-time adaptive setting. Real-time operation may be feasible by scaling up to a multi-processor environment and applying more sophisticated statistical noise reduction. Supported by Cancer Research UK ART-NET (A21993).

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VALIDATION OF A TRANSIT DOSIMETRY SOFTWARE WITH IONIZATION CHAMBER MEASUREMENTS

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Purpose: Transit dosimetry in external beam radiotherapy treatments is based on image acquisition through the patient during field irradiation with the electronic portal imaging device (EPID). PerFRACTION (Sun Nuclear Corporation) is a software for in-vivo transit dosimetry that converts the transit image to an absorbed dose distribution in the middle plane of a $50\times50\times4.9$ cm^3 water phantom. Such dose distribution can be compared with the expected dose distribution calculated by the software.

This work aims to validate the PerFRACTION algorithm for expected transit dose values with dose values determined with ionization chamber measurements under transit dosimetry conditions.

Material and methods: Forty-three treatment fields were studied, both static and dynamic. The static fields were: the nine asymmetric fields needed to calibrate PerFRACTION, three jaws-defined (20x20, 6x6 and 10x10 cm^2) and two MLC-defined fields (2x2 and 3x3 cm^2). The dynamic fields were 29 IMRT fields from 10 breast treatment plans. All fields were delivered through three different thickness solid water phantoms: 10 cm, 30 cm and a 3 cm cork slab placed between 10 cm of solid water. Hence, a total of 129 fields were analysed.

The transit dosimetry images were acquired with the EPID placed at 150 cm from the source. From every image, a representative dose value from a homogeneous region was obtained from PerFRACTION expected dose distribution.

To perform the ionization chamber measurements, a solid water phantom of 30x30 cm^2 and 5.5 cm-thick was placed on the EPID cover. The measurement point was at 150 cm distance from the source and at a depth of 2.5 cm. The phantom was moved laterally, if necessary, to reproduce the PerFRACTION representative points. IMRT and static MLC-defined fields were measured with a PTW PinPoint3D ionization chamber, while the rest with a PTW Farmer chamber.

Results: Comparison of PerFRACTION expected dose values with measured dose values, shows mean differences of 0.4±1.1% for IMRT fields (range = [-3.1%, 2.9%] and |95th percentile| = 2.3%) and 0.1%±1.2% for static fields (range = [-1.8%, 2.9%] and |95th percentile| = 2.1%).

The mean difference between different thickness phantoms varies as maximum of 0.5% for IMRT fields and -0.4% for static fields.

Conclusions: We validated the PerFRACTION algorithm for expected dose values with experimental measurements under transit dosimetry conditions for static and dynamic fields, and homogenous and heterogeneous phantoms.

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A FEDERATED LEARNING IT-INFRASTRUCTURE TO SUPPORT THE DUTCH MODEL-BASED APPROACH FOR PROTON THERAPY

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