Conclusion: A TPP was successfully developed for deliverable VMAT plans. Comparisons with Eclipse optimized plans suggest similar plan quality with some benefits for parallel OARs for the investigated cases. The flexible and new TPP allows the implementation of further functionalities in future projects.

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End to end dosimetric and geometric accuracy of a magnetic resonance guided linear accelerator

Type: Physics

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Purpose: Magnetic resonance guided linear accelerators (MR-Linac) allow for online imaging during the treatment and enable gating on the tumor position. To assess the overall dosimetric and geometric accuracy of the MRIdian MR-Linac (Viewray), end-to-end tests with three different phantoms were performed for static and moving targets.
Methods and materials: Six different treatment plans were measured in the static inhomogeneous thorax phantom (CIRS) using a Farmer chamber. Radio chromic film measurements were performed in the Lucy 3D QA phantom (Standard Imaging) for an IMRT plan with 11 fields. The gating performance of the MR-Linac was evaluated in the longitudinal direction in the dynamic thorax phantom (CIRS) using a 10-field IMRT plan. Stripes of radio chromic films were inserted into a target rod moving longitudinally with an amplitude of 15 mm within a body-like support structure. The gross tumor volume (GTV) was enlarged by 3 mm to define the gating window.
Results: Mean dose deviation in the CIRS phantom was 0.7%±0.4% compared to the planning system. The accuracy was equally good in water, lung and bone tissue surrogate. For static treatments the gamma evaluation of films in the Lucy phantom was repeated showing passing rates of 97% and 98.5% for a 5%/1 mm criteria and a passing rate of 100% for a 5%/1.5 mm criteria. The gated dose distribution showed a longitudinal offset of 1 mm relative to the static treatment and an offset of 1.5 mm compared to the planned dose distribution. The measured dose maximum was 2% lower in the gated treatment compared to the static treatment and 4% lower than the planned dose.
Conclusion: The MRIdian showed a high geometric and dosimetric accuracy which allows for precise stereotactic body treatments and accurate gating for moving targets.

Modeling and measuring clinical electron beams in magnetic fields: investigating the potential of future MR-guided electron therapy

Type: Physics

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Aims: Future integrated MR guided radiotherapy systems might profit from the availability of an electron beam mode. The aim is to model and experimentally confirm the dosimetric impact of magnetic fields on clinical electron beams for different beam energies, magnetic field strengths including two relative orientations in a water equivalent phantom.
Methods: A multiple source Monte Carlo (MC) beam model was commissioned for a Varian Clinac 2100 C linear accelerator and applied to simulate the particle transport including a magnetic field with the Geant4 MC toolkit. A permanent magnet device was used to generate a strong magnetic field up to 0.7 T encompassing a solid water phantom. Gafchromic EBT3 film was placed in the phantom for dose measurements of 6, 12 and 20 MeV electron beams in a perpendicular and parallel magnetic field orientation and a zero magnetic field reference setup.
Results: Film data confirmed MC predictions of substantial deflection of the electron beam in a perpendicular magnetic field due to the Lorentz force for all three initial energies compared to reference measurements. For a parallel magnetic field, a dose enhancement up to 100% (6 MeV beam, 0 vs. 0.7 T magnetic field) was observed in the dose profiles at different depths in the phantom.
Conclusions: An experimental and corresponding in-silico framework to measure and simulate clinical electron beams in magnetic fields of different strengths and relative orientations was established and successfully tested.

Implications of respiratory motion variability for the ITV approach in PBS proton therapy

Type: Physics

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Introduction: Motion management is a key component for pencil beam scanned (PBS) proton therapy. Currently, treatment planning and target definition for mobile tumours are still based on a single 4DCT without considering variable breathing. We aim in this analysis to assess the dosimetric impacts of motion variability, and propose a probabilistic ITV definition to account for respiratory variabilities.
Methods: CTs from two lung patients were warped using deformation vectors extracted from 4DMRI datasets of two volunteers, resulting in four pseudo-4DCT datasets covering 40 breathing cycles each. A percentage map was defined by overlaying the first 20 single-cycle ITVs. Threshold percentages (x = 0%, 25%, 50%, or 75%) were selected to define probabilistic ITVx).

Two-field PBS proton treatment plans were optimised on the four ITVs, and 4D dose distributions were calculated using the second 20 breathing cycles. In order to minimise the influence of interplay effect, 9 × volumetric rescanning was applied.