For the first time, clinical users not only could generate a SPArc plan meeting the mechanical constraint of their proton system but also directly controlled the arc treatment speed and momentum changes of the gantry during the plan optimization. This work paved the roadmap for the clinical implementation of proton arc therapy in the treatment planning platform as well as existing clinical proton therapy system equipped with arc module.

OC-0305 Acceptance procedure of a novel Flash irradiation system with standard dosimetric tools

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Purpose or Objective

FLASH radiotherapy uses ultra-high dose rates (>40 Gy/s) over a very short time period (<100 ms). Acceptance procedures for high dose rate systems are not standard and dosimetry is challenging. Common real-time detectors such as ion chambers and semiconductors present saturation behaviour at high dose per pulse due to recombination issues and fail to accurately measure dose (Di Martino F., Front. Phys. 2020). Passive detectors such as alanine, Gafchromic films, and TLDs show an agreement within 3% and no dose-rate dependency (Jorge P.G., Radiother. Onc., 2019) and are currently considered the best candidates for absolute dosimetry.

Materials and Methods

Acceptance tests were performed on a dedicated research linac for Flash radiotherapy with electron (ElectronFlash4000, SIT, Italy) at 7 and 9 MeV using standard dosimetric tools: a PTW advanced Markus (AM) plane parallel ion chamber, Gafchromic EBT XD films, and alanine pellets. The films were analyzed with a robust protocol combining open source and commercial software. The alanine pellets were read out with EPR. Measurements were performed in an adapted PTW MP3 water phantom and in solid water (RW3). Stray radiation was monitored in the bunker using Fluke 451 B and Camberra Babyline 81 survey meters, while neutron production was considered negligible at these energies. The system is highly tunable for pulse length, pulse repetition frequency and number of pulses and allows to reach DR_{max}=2.2 kGy/s and DR_{min}=44 mGy/s in Flash and conventional mode, respectively. Measurements are performed in fields of 40, 100 (reference), and 120 mm in diameter.

Results

The system passed all standard safety and mechanical checks. Stray radiation from a RW3 phantom never exceeded 2.5 10^{-5} Sv/MU at 1 m. Performance tests assessing dose, dose stability, PDD, profiles, and output linearity to system settings were measured with at least two detectors. Results from alanine and films were comparable within 5%. Energy and dose outputs were monitored for 5 days with films and AM and were stable within 5%.

The AM show saturation above 2 Gy/pulse. This effect is reduced when decreasing the dose per pulse by placing the detector at larger SSDs. The dose per pulse follows the inverse square law with R=1, allowing the use of greater SSDs to reduce the recombination effect. We assumed that the low electron scatter condition are achieved by the focusing technique of the linac. The measured correction value k_{sat} showed a good agreement (2%) with the model proposed by Di Martino (Med. Phys. 2005) for dose up to about 0.8 Gy/pulse. The validation of the model supports using the AM for dosimetric daily QA of the ElectronFlash.

Conclusion

Here we present a protocol for the acceptance of the dedicated ElectonFlash linac using standard dosimetric tools. We propose the use of alanine as absolute dosimetric standard combined with Gafchromic films. The AM could be employed as a real-time tool for daily QA upon validation of the inverse square law and modeling of the chamber in use.

OC-0306 Performance evaluation of BgRT delivery directed at multiple PET-avid targets

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Purpose or Objective

Biology-guided radiotherapy (BgRT) incorporates PET detection hardware into a ring-gantry LINAC for real-time tracking treatment. During active beam delivery, the system operates by aiming beamlets of therapeutic radiation at malignant tumors in response to PET emissions emanating from these tumors. These beamlets sum to the intended dose prescribed by the physician. BgRT utilizes a unique volume, the biology-tracking zone (BTZ), to delineate the space from which PET emissions are acted upon so that radiotherapy beamlets are not directed to PET-avid organs-at-risk. Phantom evaluation of BgRT multi-target scenarios and the utility of the BTZ to segregate targets from nearby non-target structures with FDG-avidity have not yet been reported.

Materials and Methods

A two-target, FDG fillable insert was created to fit inside the bore of the ArcCHECK phantom. The insert comprised of a 22 mm diameter spherical target located 39 mm off-axis (IEC-X) and a 26 mm axial length C-shape target located 19 mm off-axis (IEC-X). The targets were 58.5 mm far apart on the IEC-X axis. Both the spherical and C-shape fillable objects were filled with fluorodeoxyglucose (FDG) to achieve an 8:1 target/OAR-to-background concentration ratio. Two different BgRT plans were created on the RefleXion treatment planning system (TPS): a) spherical target with a nearby PET-avid C-shape structure, representing an organ at risk (OAR) and b) a cylindrical target enclosing the C-shape object, representing a partially PET-avid tumor. For each plan, the BTZ was drawn enclosing the target, while excluding nearby PET-avid structures. On a pre-commercial version of the RefleXion system, using the same FDG fill, both BgRT plans were delivered, back-to-