Reporting Physics Requirements and Independent Quality Assurance Results for Credentialing Single- or Multi-Institutional SFRT Clinical Trials for Large and Unresectable Bulky Tumors

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INTRODUCTION

We present the results of anthropomorphic phantoms (IROC Houston) irradiations at 2-academic institutions for independent verification of highly heterogenous dose distributions via 3D MLC-based SFRT plans for credentialling multi-institutional site-specific clinical trials for debulking large (≥ 8 cm) unresectable tumors.

METHODS

After completing comprehensive in-house testing, validation and technology/facility questionnaire, a total of 6 IROC standard photon phantoms (head and neck, lung, liver, pelvis, 2 SRS head phantoms) were irradiated by 2-academic institutions for benchmarking and participating in site-specific SFRT clinical trials. For a single-dose of 15 Gy, highly heterogenous 3D static MLC-based SFRT plans were generated with 6-crossfire 6MV beams, AcurosXB dose-engine and delivered same-day via IGRT clinical workflow on TrueBeam LINAC similar to SBRT. Phantoms were sent back to the IROC for blind review, audits and independent dose verification.

INNOVATION & CLINICAL IMPACT

The SFRT treatment which delivers a single dose of 15-20 Gy with unconventional highly nonuniform dose distributions, with steep dose gradient has shown high rates of clinical response with minimal toxicities in large-volume (≥ 8 cm) primary or metastatic tumors. However, prospective multi-institutional site-specific clinical trials in SFRT delivery are lacking, and the SFRT techniques and reporting dose parameters remain variable. To address some of these concerns, we report on the physics requirements of credentialling and independent QA for single- and multi-institutional clinical trials in SFRT treatment to help facilitate development and enhance the feasibility of such trials at 2-academic institutions. For independent dose verification, we used IROC standard photon phantoms (example SFRT plan: SRS head phantom, Figure 1) with 3D MLC-based crossfire method via 6MV beams & Acuros-XB dose calculation algorithm in Eclipse TPS.

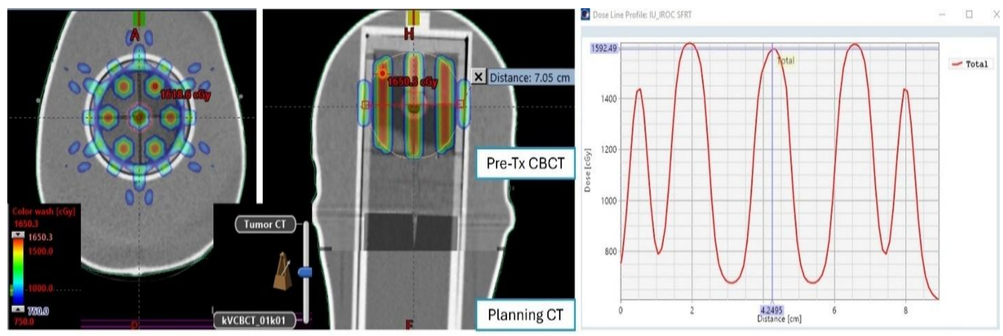

Figure 1: Demonstration of an example case, superimposing pre-Tx CBCT images with 3D MLC-based SFRT credentialling plan of SRS head phantom from IROC MD Anderson QA Center, Houston, TX (Institution 1). A single dose of 15 Gy of nominal prescription (hotspot 110%) was prescribed for this SFRT plan & delivered via pre-Tx CBCT IGRT verification & 6DOF couch corrections for set up & verification on TrueBeam LINAC with standard 5 mm MLC. On the right panel–peak-to-valley dose ratio through the isocenter in the coronal view is shown. This SRS phantom irradiation passed the independent dose verification within +/-1% point dose measurements with TLDs & within 98% of coronal & sagittal films inserts [gamma index criteria of 5%/3mm].

RESULTS

The measured vs calculated dose to the center of the target for head and neck phantom with 6 TLDs inserts in target were 0.96–1.04. More than 98% of points met IROC gamma-index criteria of 5%/3mm in both coronal and sagittal planes. The organ-at-risk TLD readings were within ±2%. For lung, liver, pelvis phantoms, each of them had 2 TLDs inserts, the measured vs calculated dose agreed within ±5%, ±4%, ±2%, respectively and films with greater than 98% agreements for all SFRT benchmarking plans in both sagittal and coronal planes. The SRS head phantoms irradiated in both institutions had absolute doses pass rates of within ±1% and greater than 98% agreements in the coronal & sagittal films.

Table 1: Illustrations for each phantom type of irradiation results from IROC (MD Anderson QA Center, Houston) of 3D MLC-based SFRT delivery via Acuros-based Eclipse TPS for both institutions (Inst.). IROC point dose verification and gamma index criteria were 0.95–1.05 and 5%/3mm, respectively. Head & Neck, Lung, Liver phantoms were irradiated Inst. 2.

Dosimetry System	Head & Neck	Lung	Liver	Pelvis	SRS head (Inst. 1)	SRS head (Inst. 2)
*TLDs (measured vs calculated)	0.96 – 1.04	1.04	1.03	1.02	1.01	1.02
GAFChromic Films (coronal/sagittal) [%]	99.3/98.0	98/97	98.4/97.8	100/100	100/96	100/99

***Head & neck phantom had 6 TLDs, Liver phantom had 4 TLDS & all other phantoms had 2 TLDs inserted in the target area.**

Table 1/Figure 1 summary: As of now, IROC doesn't provide specialized phantoms for independent dose verification and audits of SFRT treatment plans for prospective clinical trials. Due to the highly heterogenous dose-distributions of SFRT plans, steep dose gradient and tissue heterogeneities, it is very challenging to pass the IROC tests via standards photons phantoms. However, with careful imaging, planning and IGRT-based delivery one should be able to be benchmarking (see Figure 1 and Table 1) & credentialing the site-specific SFRT prospective clinical trials via standard IROC photon phantoms for initiating single- or multi-institutional trails for both palliative and curative SFRT treatments with combination therapy.

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CONCLUSIONS

- Utilizing the standard IROC photon phantoms, we achieved successful pass rates of independent dose verification of highly heterogenous SFRT plans with steep dose gradient for site-specific prospective trial validation, testing & benchmarking.
- These results support starting site-specific single- or multi-institutional prospective SFRT clinical trials for treating site-specific large tumors with combination radiotherapy and/or immunotherapy.

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