

Evaluation of a hybrid pre-treatment QA technique for single isocenter plans for multiple lesions SRS treatments

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INTRODUCTION

Stereotactic radiosurgery (SRS) is a hypofractionated high dose treatment aimed to treat small lesions deemed to be surgically inoperable. Linac based single isocenter SRS is gaining popularity over other treatment modalities (linac-based with multiple isocenters, Gamma Knife, Cyber Knife) due to its rapid delivery with comparable tumor control benefits [1]. However, using a single isocenter for multiple beams/arcs to treat multiple lesions poses challenges for pre-treatment patient QA. High dose with steep gradients around the targets and the requirement of strict spatial tolerance for patient specific QA augment these challenges [2,3].

The measurement of dose distribution for such complex plans therefore requires high spatial resolution dosimeters. The suitable candidates for this purpose are 3D gel dosimeters [4], EPID based dosimetry systems [5], radiochromic films [6] or computational dosimetry algorithms utilizing log and/or EPID based files from the linear accelerators [7].

PerFRACTION is a hybrid measurement-calculation EPID-based dose reconstruction system, which acquires the MLC apertures from the EPID generated files and gantry angles from the time resolved accelerator log files. Fluence information is acquired from the RT-Plan. These data are fed into a GPU-based superposition algorithm for dose reconstruction on a patient CT.

AIM

This study's aim was to evaluate a commercial hybrid dosimetry system for dose verification of single isocenter SRS treatments of multiple lesions.

METHOD

- Treatment Planning:** Three SRS plans (T3, PT3 & PT5) were generated on PMMA multiplug phantom (figure 1 (a)). The multiplug was encased in a shell resulting in an outer diameter of 26.6 cm. It has multiple inserts for ion chambers and one film insert of size 13.2 x 16.5 cm².
- The plans had 3, 3 and 5 targets, respectively, with size ranging from 0.75-3.6 cm. The targets were oriented in such a way that at least one film plane intersects the target at its center (figure 1 (b)). The isocenter was placed at the center of the multiplug. An additional 2cm diameter structure was contoured at isocenter.
- VMAT plans were optimized using Pinnacle v. 14.0 with 6FFF MV beams at a dose rate of 1400 MU/min. At most part, RTOG 0320 protocol was employed to prescribe the dose to small targets. Each plan had four arcs (2 coplanar and 2 non-coplanar). The non-coplanar arcs had $\pm 25^\circ$ couch orientation. The dose was calculated at 2° control point.
- PerFRACTION dose reconstruction:** The TPS plans were transferred to the machine, TrueBeam v. 2 equipped with 120 leaf Millennium MLC and amorphous silicon based EPID (aSi 1000). The plans were delivered on EPID without couch. The EPID and log files were acquired from the console computer while the DICOM CTs along with RT-Plan and RT-Dose files were exported from the TPS. All files were uploaded to the PerFRACTION server to reconstruct dose in the given CTs. The reconstructed dose was imported into Pinnacle to extract required planes.
- Measurements and analysis:** Gafchromic EBT-XD films were used to measure the dose. The films were calibrated in a solid water phantom using 6 MV beam. Total 7 film planes were measured for the three plans in selected planes. Ion chamber (vol. 0.057cc) measurements were performed for each plan at isocenter. These dose values were used to scale the films.
- Scanning was performed after 24 hours of irradiation using flatbed 48 bit color document scanner. RIT113 v 6.6 was used for film analysis. Films were registered to the reconstructed dose using film fiducials. Global gamma at 3%/1mm and 2%/2mm criteria with 10% low dose threshold were performed based on Depuydt et al. [8] with filter level 3.

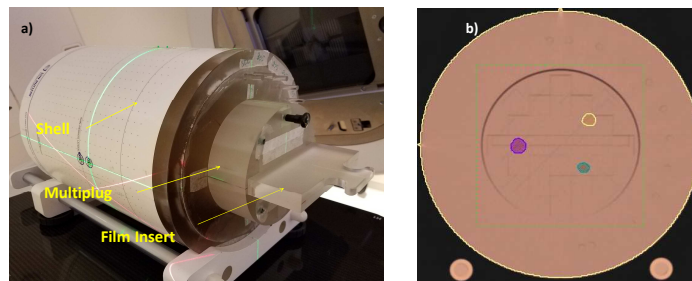


Figure 1: a) PMMA Multiplug phantom with dummy shell b) The orientation of spherical targets in the selected planes.

RESULTS

- The gamma analysis for all measured film planes are presented in Table 1. The average passing rates for 3%/1mm and 2%/2mm at global normalization were $99.45\% \pm 0.98\%$ and $99.19\% \pm 1.55\%$, respectively.
- The minimum gamma of 95.77% was observed for the five target plan at 2%/2mm criteria. Figure 2 shows the gamma map for this case along with the isodose overlay. The disagreement can be observed at the edges of the large target (dia. 3.6 cm) and in the low dose region.
- PerFRACTION vs. Pinnacle showed an excellent agreement at both 2%/2mm (99.93%) and 3%/1mm (100%).

Table 1: Results for the gamma comparison between PerFraction reconstructed dose and the EBT-XD film measurements.

Plan	Plane	PerFRACTION vs. Film	
		3%/1mm	2%/2mm
T3	Oblique 45	99.98	99.98
	Oblique 135	99.92	99.93
PT3	Oblique 45	99.99	99.99
	Oblique 135	99.97	100
PT5	Coronal	99.38	99.05
	Oblique 45	99.65	99.59
	Oblique 135	97.28	95.77

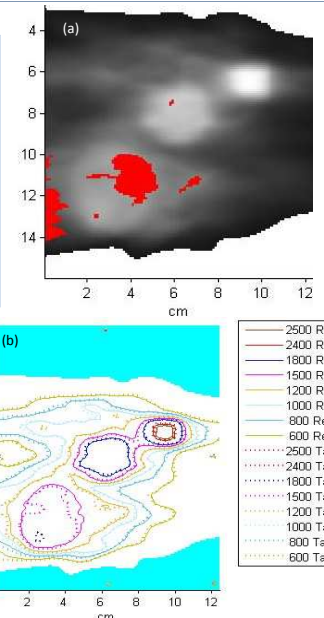


Figure 2: Gamma map (a) and isodose overlay (b) for PT5-Oblique 135 plane at 2%/2mm gamma level.

CONCLUSIONS

- An EPID based hybrid dose reconstruction system (PerFRACTION) was evaluated for the single isocenter multi-lesion SRS treatments.
- The gamma analysis for PerFRACTION reconstructed dose vs. Gafchromic film measurements showed good agreement at a stringent criteria of 3%/1mm.
- The results suggest that the PerFRACTION is feasible for the pre-treatment dose verifications in such treatments.

ACKNOWLEDGEMENTS

- This work is partly supported by Sun Nuclear Corporation.

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