Comparative Study of SRS End-to-End QA Processes of a Diode Array Device and an Anthropomorphic Phantom Loaded with Extended Range Radiochromic film

S.B. Lim, M.F. Chan, L. Kuo, T. Li, X. Li, A. Ballangrud, and D.M. Lovelock
Memorial Sloan Kettering Cancer Center, New York, New York

JULY 12–16 2020 VIRTUAL JOINT AAPM | COMP MEETING
EASTERN TIME [GMT-4]

INTRODUCTION

End-to-end testing (E2E) is a necessary process for assessing the readiness of SRS program and annual QA of an SRS system[1]. Anthropomorphic phantom film-based approach has been the gold standard for E2E test. However, the intensive work required to perform the film-based E2E tests, especially in a large hospital network, can be prevent them from being broadly implemented.

AIM

In this study, we investigated the feasibility of using a two-dimensional detector array, SRS MapCHECK (SRSMC), in phantom to replace anthropomorphic phantom film-based setup in performing regular stereotactic radiosurgery (SRS) end-to-end test (E2E) recommended by the AAPM MPPG #9a in a large hospital network to augment the workflow efficiency

METHOD

Three SRS capable LINACs (Varian Medical Systems, Palo Alto, CA) at three different sites were chosen to represent a hospital network, Trilogy with M120 multi-leaf collimator (MLC), TrueBeam with M120 MLC, and TrueBeam Stx with HD120 MLC. An anthropomorphic STEEV phantom (CIRS, Norfolk, VA) and a phantom/diode array: StereoPHAN / SRS MapCHECK (Sun Nuclear, Melbourne, FL) were CT scanned at each site. The new STV-PHANTOM EBT-XD films (Ashland, Bridgewater, NJ) were used. SRS cranial plans using dynamic conformal arc and volumetric-modulated arc therapy, with 1-4 targets, were planned with Eclipse v15.5 TPS using a custom SRS beam model for each machine. All phantoms were delivered using image-guided delivery. The dosimetric and localization accuracy were compared. The time of analyzing the two systems by three teams of physicists was also compared to assess the throughput efficiency.

RESULTS

With film, the dose difference (ΔD) from the three sites were found to be within ±3.7%. The maximum localization errors (E_{local}) were found to be within 0.5 mm and 1.0 mm for TrueBeam and Trilogy, respectively. With SRSMC, the ΔD was found to be within 5% from the TPS calculation. E_{local} were found to be within 0.7 to 1.1 mm for TrueBeam and Trilogy, respectively. Comparing with film, an additional uncertainty of 0.7 mm was found with SRSMC. The delivery and analysis times were found to be 6 and 2 hours for film and SRSMC, respectively.

Both film-based anthropomorphic phantom (Figure 1a) and SRSMC (Figure 1b) based E2E tests were performed at three clinics of a large hospital network. Figure 2a shows the corresponding dose difference (ΔD) analysis between film and the treatment planning system calculation (TPSC). Figure 2b shows similar analysis from SRS MapCheck. Table 1 shows the dosimetric and the localization error, E_{local}, of the systems. The SRSMC showed comparable dosimetric performance with film. The E_{local} of the SRSMC showed about 0.7mm deviation from film results. In terms of time, the delivery and analysis time for film and SRSMC were found to be 6 hours and 2 hours, respectively. The shorter turnaround time of SRSMC provides a higher efficiency workflow. For the MPPG #9a application, however, the localization of uncertainty of SRSMC will require further investigation in terms of reproducibility and target size sensitivity.

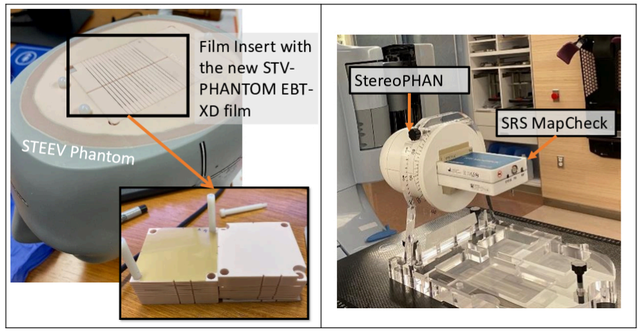

Figure 1: (a) film-based anthropomorphic phantom with film insert shown in the insert; (b) SRS MapCHECK in StereoPHAN.

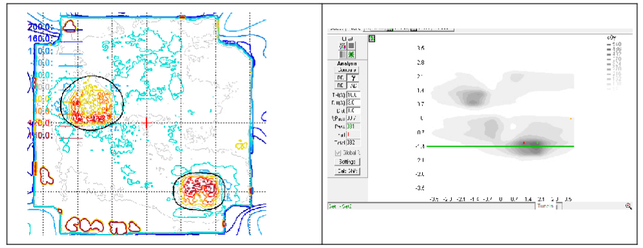

Figure 2: Film based anthropomorphic phantom E2E and SRS MapCheck results: (a) ΔD of film and TPSC.; (b) ΔD of film and TPSC.

Table 1: Dosimetric and localization error comparisons between anthropomorphic phantom with film and SRSMC; ΔD is defined as the percentage difference between detector (film or SRS Mapcheck) with TPS within the 90% of prescription isodose lines.

Machine	Film	Film E_{local} (mm)			SRSMC	SRSMC E_{local} (x, y, z in mm, p, r, y in degree)					
	ΔD (%)	x	Y	Z	ΔD (%)	x	Y	z	p	R	Y
1: TB HD120	3.7	0.0	0.0	0.3	1.5	0.0	0.7	0.4	0.2	0.5	-0.1
2: TB M120	-3.1	0.2	0.5	0.3	-0.5	0.2	0.0	0.8	0.5	0.0	0.3
3: CL M120	-3.2	0.4	0.3	0.4	-4.9	0.9	1.1	0.9	0.0	0.0	0.2

DISCUSSIONS

The gamma passing rate from all our measurements were similar to the recent study[2]. The absolute dose reported by both systems also agreed with each other within measurement uncertainty. However, the localization error calculated by SRS Mapcheck software is slightly than higher film-based system. Although the localization differences between the two systems are < 1.0mm, this can have significant impacts on SRS treatments and warrants further investigation.

CONCLUSIONS

The SRS MapCHECK agrees dosimetrically with film within measurement uncertainties. However, film shows superior sub-millimeter localization resolving power for the MPPG# 9a implementation.

ACKNOWLEDGEMENTS

1. This work was partially supported by the MSK Cancer Center Support Grant/Core Grant (P30 CA008748).

REFERENCES

1. Halvorsen, P.H., Cirino, E., Das, I.J., Garrett, J.A., Yang, J., Yin, F.-F. and Fairobent, L.A. (2017), AAPM -RSS Medical Physics Practice Guideline 9.a. for SRS -SBRT . J Appl Clin Med Phys, 18: 10-21. doi:10.1002/acm2.12146

2. Rose, M.S., Tirpak, L., Van Casteren, K., Zack, J., Simon, T., Schoenfeld, A. and Simon, W. (2020), Multi-institution validation of a new high spatial resolution diode array for SRS and SBRT plan pretreatment quality assurance. Med. Phys.. doi:10.1002/mp.14153

CONTACT INFORMATION

Seng Boh Lim
Email: lims1@mskcc.org