Clinical Implementation and End-To-End Testing of Varian SRS Cones





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INTRODUCTION

Small fields used in external beam therapy continue to be a clinical challenge. According to a study published by Kry et. al. (2017) in the International Journal of Radiation Oncology Biology and Physics, the output factors for these small fields continue to be the area of largest dosimetric failure, with half of all studied institutions outside of tolerance. The lack of industry guidelines dedicated to the measurement and clinical implementation of small fields, with MPPG 9a being the only resource dedicated to small fields until the recent publication of IAEA TRS 483, compounds the challenge of integrating tools such as SRS cones into the clinic. This poster presents a method for implementing and verifying Eclipse Treatment Planning System (TPS) dose calculations for Varian SRS cones.



RESULTS

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Cone Size	Plan Energy	Plan MU	Plan Dose (cGy)	Measured Dose			% Difference		
				EDGE SW	EDGE WT	PTW	EDGE SW	EDGE WT	PTW
17.5 mm	6MV	1288.7	999.2	983.35	999.99	981.11	-1.59	0.08	-1.81
	6FFF	1310.2	999.2	987.40	994.49	986.91	-1.18	-0.47	-1.23
15 mm	6MV	1313.6	999.8	982.05	999.55	978.98	-1.68	0.08	-2.02
	6FFF	1331.5	999.0	986.42	994.67	972.73	-1.26	-0.43	-2.63
12.5 mm	6MV	1354.2	997.8	982.07	1001.88	978.58	-1.58	0.41	-2.02
	6FFF	1364.7	998.4	986.02	995.71	971.43	-1.24	-0.27	-2.70
10 mm	6MV	1415.8	995.4	979.89	1003.35	977.20	-1.56	0.80	-2.06
	6FFF	1414.8	996.4	985.36	995.92	970.27	-1.11	-0.05	-2.62
7.5 mm	6MV	1524.4	988.0	970.26	1003.17	976.82	-1.80	1.54	-1.87
	6FFF	1504.4	989.0	981.49	995.48	983.75	-0.76	0.66	-0.53
5 mm	6MV	1770.8	962.9	938.79	994.41	982.33	-2.50	3.27	-0.57
	6FFF	1710.3	966.0	971.15	987.64	998.65	0.53	2.24	2.83
4 mm	6MV	1982.1	940.2	910.20	1003.87	985.85	-3.19	6.77	2.38
	6FFF	1891.7	942.4	953.34	977.43	1007.62	1.16	3.72	6.92

METHODS & MATERIALS

The output factors for a set of Varian SRS cones were measured through a previous study. The output factors used for the TPS were those measured by the Sun Nuclear EDGE detector. The initial cone output factors were not corrected for detector specific effects as recommended by IAEA TRS 483 and were not applied in this study.

The cones included in this poster have diameters of 17.5mm, 15mm, 12.5mm, 10mm, 7.5mm, 5mm,



Table 1. Comparison between TPS calculated dose and measured dose. A +/- percent difference indicates a larger/smaller measured dose than the TPS calculation. "SW" and "WT" indicate EDGE detector measurements in Solid Water and a Water Tank.

Cone Size	Plan Energy	Plan MU	RadCalc® MU	MU % Diff	Plan Dose (cGy)	RadCalc® Dose (cGy)	Dose % Diff
17.5 mm	6MV	1288.7	1301.9	1.02	1000.20	990.05	-1.01
	6FFF	1310.2	1313.8	0.27	999.20	996.47	-0.27
15 mm	6MV	1313.6	1330.6	1.29	999.80	986.99	-1.28
	6FFF	1331.5	1332.6	0.08	999.00	998.71	-0.03
12.5 mm	6MV	1354.2	1369.7	1.14	999.80	988.54	-1.13
	6FFF	1364.7	1368.6	0.29	996.40	993.58	-0.28
10 mm	6MV	1415.8	1421.3	0.39	1000.40	996.53	-0.39
	6FFF	1414.8	1405.3	-0.67	996.40	1003.12	0.67
7.5 mm	6MV	1524.4	1537.1	0.83	1000.00	991.66	-0.83
	6FFF	1504.4	1495.7	-0.58	999.80	1005.38	0.56
5 mm	6MV	1770.8	1782.2	0.64	999.58	993.21	-0.64
	6FFF	1710.3	1704.9	-0.32	1000.00	1003.13	0.31
4 mm	6MV	1982.1	1994.9	0.65	1000.22	993.86	-0.64
	6FFF	1891.7	1891.9	0.01	1000.32	1000.23	-0.01

and 4mm. For each cone size, a set of plans was created using Eclipse Cone Planning for both 6MV and 6FFF energies. Each plan consisted of two arcs: one 50° arc and one 80° arc. Plans were calculated in a 40cm x 40cm x 40cm cubic water phantom at 95cm SSD with the calculated point dose on the central axis at 5cm depth.

The EDGE detector and the PTW 60012 stereotactic diode were used as two independent methods of verifying dose. Measurements with the PTW diode were made in a Sun Nuclear 1D SCANNER water tank. Measurements with the EDGE detector were made in both the 1D water tank as well as a custom-milled slab of solid water. Setup for both detectors mirrored the TPS calculation setup with 95cm SSD and the detector placed at 5cm depth along the central axis.

Both the EDGE detector and PTW diode were cross calibrated with an Exradin A12 ion chamber to correlate between charge collected by the diode and dose. This cross-calibration was completed before Table 2. Comparison between TPS calculated MU and dose and RadCalc calculated MU and dose. A +/- percent difference indicates a larger/smaller RadCalc calculation than the TPS calculation.

Discussion

Point dose measurements with both detectors shows an increase in measured dose as the cone diameter decreases. This effect is most notable at the 4mm and 5mm diameter cones. This trend is largely due to calibrating each diode at a 10cm x 10cm field size. As field size decreases, both the EDGE detector and PTW 60012 diode show a significant over response. This response has been characterized by other groups through experimental methods and Monte Carlo simulations and correction values were tabulated in the recently published IAEA TRS 483 report. It is expected that the absence of these correction factors for the diode over response is responsible for the significant percent difference between the measured dose and calculated dose. There is also a notable difference between the solid water and water tank EDGE measurements. This is expected to be due largely to setup uncertainties with the solid water. While the slab of solid water was custom milled for the EDGE detector, the detector was still able to slightly move in its holding. Any movement away from the central axis after the initial setup may have gone unnoticed while any movement in the water tank was easily discernible and corrected. Interestingly, we also noted a significant difference between the dose measured from the 50 degree arc and the 80 degree arc. The dose measured for the 50 degree arc was constantly greater than that for the 80 degree arc. This discrepancy had minimal effect on the dose for the entire treatment plan and was not investigated in this study.

each measurement to minimize and day-to-day environmental dependencies of the diode detectors. The cross-calibration was completed at 90cm SSD, reference depth of 10cm, and 10cm x 10cm field size. A linear relationship between collected charge and dose was then assumed for each detector. RadCalc® software was also commissioned for independent MU and point dose calculation. The RadCalc® software was then used as another method of verifying the TPS dose calculation.

Figure 1. Dose distributions of 6MV plans for the 4mm cone (top), 10mm cone (middle), and 17.5 mm cone (bottom). 50 degree and 80 degree arcs are shown as well as the calculation/measurement point at 5 cm depth along the central axis.