UNC HEALTH CARE

Evaluation of the RayStation Monte Carlo dose algorithm for small-field surface-collimated electrons

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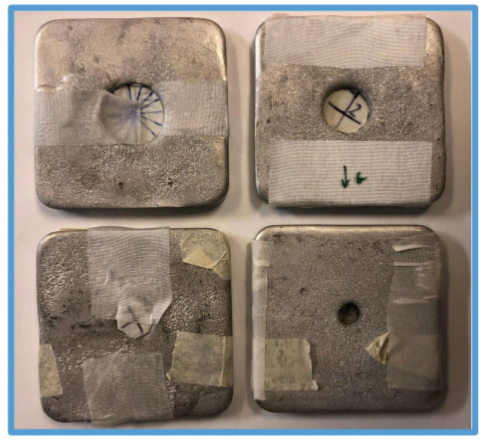
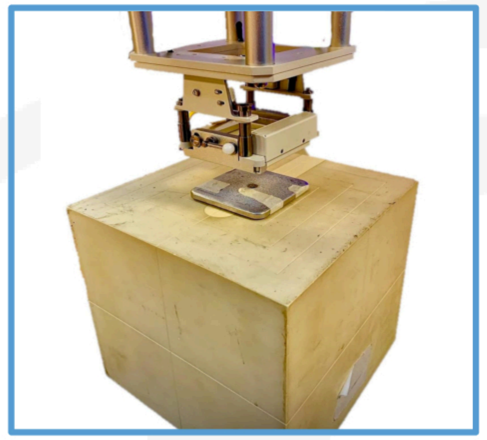
Introduction

Low-energy kV beams are a standard method of treatment for superficial skin lesions, but not all clinics have access to superficial/orthovoltage treatment units. However, most modern LINACs can deliver electrons and adding surface collimation reduces the penumbra width and thus increases the useable proportion of the beam. This is especially important for small fields, where most of the field area is lost to penumbra. RayStation has a Monte Carlo algorithm which has been extensively evaluated for applicator-mounted cutouts, but not for small-field surface collimation. The goal of this project is to test RayStation in the setting of small-field surface-collimated electron beams.

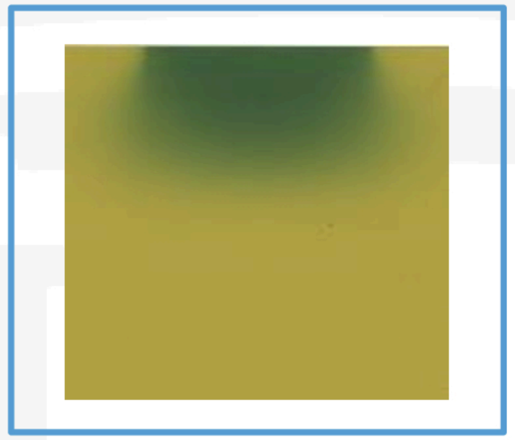
Methods



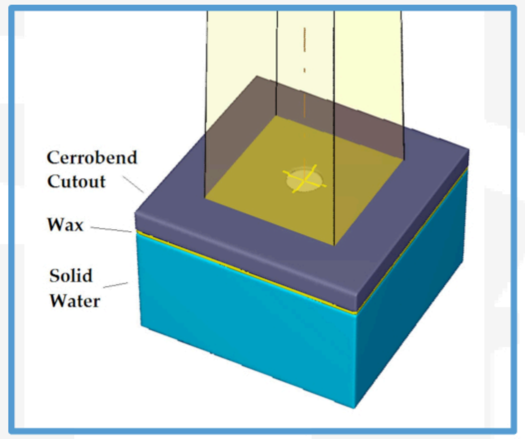
Poured cerrobend cutouts with holes of 10, 15, 20, and 30 mm (nominal diameter). Cut 5- and 10-mm thick bolus to fit holes. Placed 1.5 mm of beeswax underneath cutouts to reduce hotspots.



Set cutouts on top of solid water, with the top of the solid water set to 100 cm SSD. A standard 6x6 cm² applicator was placed in the LINAC head.



Measured profiles, depth dose curves, and output factors w/ GAFChromic™ EBT3 film. Pieces of film were placed perpendicular and parallel to the beam.



Simulated electron irradiation setup using RayStation's electron Monte Carlo. Each cutout and bolus combination was simulated with 5 million histories.

Results

		Output factor and isodose line comparisons between RayStation and film measurements						
		10 mm Hole	15 mm Hole		20 mm Hole		30 mm Hole	
		5 mm Bolus	5 mm Bolus	10 mm Bolus	5 mm Bolus	10 mm Bolus	5 mm Bolus	10 mm Bolus
Measured diameter of cutout hole		10.2	14.7	14.7	21.7	21.7	29.1	29.1
Measured thickness of cutout (mm)		7.7	9.4	9.4	7.0	7.0	8.0	8.0
Sagittal film, measured dmax (mm)		1.0	1.5	0.0	3.4	1.2	6.9	1.9
RayStation, calculated dmax (mm)		0.0	0.0	0.0	3.6	0.0	6.5	1.5
Depth of nominal dmax (mm)		0.0	2.0	0.0	4.0	0.0	7.0	2.0
Output factors at nominal dmax	Film	0.783	0.767	0.831	0.857	0.866	0.825	0.832
	RayStation	0.813	0.815	0.808	0.827	0.838	0.847	0.855
	% Difference	**3.7%**	**5.9%**	**-2.9%**	**-3.7%**	**-3.4%**	**2.6%**	**2.6%**
R90 along CAX (mm)	Film	3.6	6.1	3.0	8.8	4.1	11.5	5.8
	RayStation	2.8	5.7	2.2	9.0	4.4	11.3	6.3
	Difference	**0.8**	**0.4**	**0.8**	**-0.2**	**-0.3**	**0.2**	**-0.5**
Width of 90% IDL at nominal dmax (mm)	Film (avg)	7.1	9.8	7.8	14.8	15.1	18.3	18.7
	RayStation	6.1	9.4	8.3	14.2	15.6	18.9	20
	Difference	**1.0**	**0.4**	**-0.5**	**0.6**	**-0.5**	**-0.6**	**-1.3**
R80 along CAX (mm)	Film	5.2	8.0	4.3	10.8	5.9	13.9	8.1
	RayStation	4.5	7.6	3.7	11.1	6.4	13.3	8.3
	Difference	**0.7**	**0.4**	**0.6**	**-0.3**	**-0.5**	**0.6**	**-0.2**
Width of 80% IDL at nominal dmax (mm)	Film (avg)	8.1	11.6	10.8	17.5	18.4	22.9	22.9
	RayStation	7.4	11.2	10.6	16.6	17.7	23.1	24.1
	Difference	**0.7**	**0.4**	**0.2**	**0.9**	**0.7**	**-0.2**	**-1.2**

Table 1: Comparison of output factors, R90, R80, and width of 90% and 80% isodose lines for each combination of cutout and bolus thickness

The measured film output factors agreed to within 6% of RayStation. R90 and R80 depths were within 1.0 mm of those calculated by RayStation. Measured widths of the 80% and 90% isodose lines differed from RayStation by a at most 1.3 mm.

MobileMOSFETs (Best Medical) were used to collect secondary data, for all except the smallest (10 mm) field. MOSFET data were found to be within 6% of RayStation. All but one of the measurements were within 3% of RayStation.

Conclusions

For the geometries tested in this project, the Monte Carlo dose algorithm in RayStation can be utilized to determine the output to a dosimetric accuracy of 6%. The measured isodose lines were within 1.3 mm of RayStation.

Future work will involve investigating the effects of obliquity and material heterogeneity.

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