



Image-guided Intra-Operative Radiation Therapy: Validating Radiance Treatment Planning System

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INTRODUCTION

- Mobetron is used for intra-operative radiation therapy treatments (IORT).
- IORT current workflow typically consist of a quick hand calculation without a calculated treatment plan.
- In an effort to provide image-guided IORT (IG-IORT) IntraOp and GMV have, respectively, developed plastic cones for Mobetron and an electron Monte Carlo treatment planning software (Radiance).

AIM

- To validate Radiance with plastic cones measurements with the overall objective of potentially using these developments for IG-IORT treatments.

METHOD

- This study was a two-step process. First, determine dose calculation parameters and then, compare dose measurements between Radiance Treatment planning system and film.

First Study:

- Radiance dose calculation parameters were optimized to best match our institution's PDD commissioning data for a single energy (6 MeV) and cone size (8cm).
- Ten scans were computed and compared with the commissioning data.
- Various parameters were used to compare to OSU commissioning data (Table 1). These parameters were broadly divided in three categories: MC Algorithm, Contour, Density assignment

PDD Runs	MC Algorithm		Contour			Density Assignment		
	MC Het	MC Water	No Contour	Contour	Virtual Phantom	No Density	Water	Solid Water
1		X		X		X		
2	X			X		X		
3		X		X			X	
4	X			X			X	
5		X	X			X		
6	X		X			X		
7		X		X				X
8	X			X				X
9		X			X		X	
10	X				X		X	

Table 1: A total of 8 different parameters were used in determining the plan that most closely represented OSU commissioning data.

Second Study:

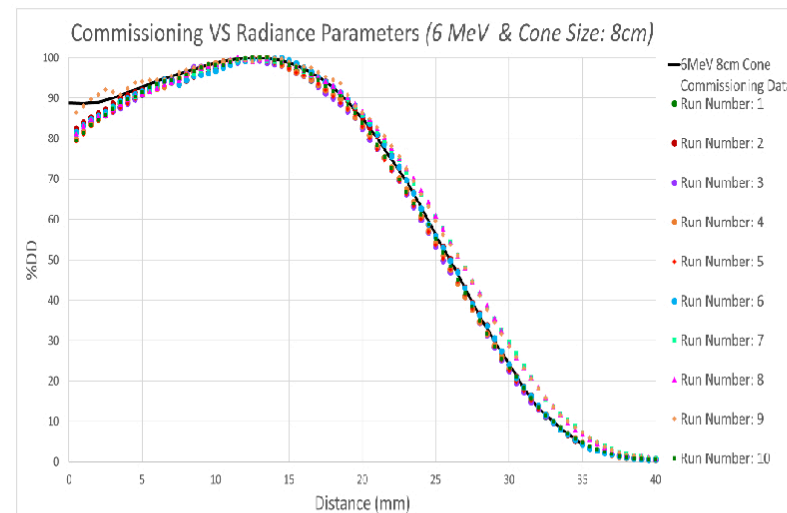
- Dose measurements in solid water were made using plastic cones (10cm or 4cm).
- A total of 6 exposures were performed on the Mobetron system using either 6MeV, 9MeV or 12MeV energies. Each exposure was designed to deliver 400 MU at dmax.
- Doses at four different depths were measured in a single exposure by placing EBT3 films in-between the solid water slabs.
- Depths ranged from 11-24mm, 17-37mm and 20-36mm for 6MeV, 9MeV and 12MeV, respectively.
- Measured dose from EBT3 films were compared with Radiance calculated values using the parameters found in the first part of the study.

RESULTS

First Study:

- Ten scans were ran with different parameters (shown in Table 1)
- The percent differences at each integer depths were compared with commissioning data for each of the 10 different parameters (shown in Table 2).
- In generally, smaller variances between the scans were found near dmax.
- Larger variances were shown at the surface and at deeper depths (shown in Figure 1).
- Larger variances at deeper depths were seen due to the simple fact of comparing smaller values.
- The average percent difference for each run ranged from 1.1% to 5.3%.

Figure 1:
Commissioning Vs. Radiance Parameters. The black line represents OSU commissioning data compared to 10 different scans. In generally greatest agreement was shown at the surface



Depth (mm)	PDD RUN NUMBER										Variance
	1	2	3	4	5	6	7	8	9	10	
1	7.9	5.4	7.7	8.0	8.4	6.1	6.6	7.9	5.9	7.7	1.1
2	4.8	3.0	4.5	4.7	5.2	3.6	4.0	5.4	3.1	4.3	0.6
3	3.5	1.5	3.5	3.0	3.8	2.4	2.7	3.8	3.6	2.3	0.6
4	2.9	0.8	3.0	2.2	3.1	1.6	2.0	3.4	4.3	1.5	1.1
5	2.1	0.9	2.0	1.8	2.0	1.2	2.0	2.9	4.0	0.8	0.9
6	1.2	0.5	1.1	1.9	1.4	0.7	1.8	2.7	4.9	0.2	1.9
7	1.0	1.3	1.0	1.5	1.2	1.5	1.4	3.0	5.1	0.5	1.8
8	0.6	2.3	0.6	0.9	0.5	2.3	1.2	4.1	4.9	0.4	2.6
9	0.3	1.9	0.0	0.5	0.1	2.0	1.0	4.5	5.0	0.4	3.3
10	1.0	1.6	0.8	0.1	0.8	1.8	0.6	3.9	5.3	0.1	2.9
11	1.0	0.9	1.0	0.3	1.1	1.1	0.3	3.6	5.5	0.0	2.9
12	0.5	0.4	0.5	0.4	0.5	0.7	0.3	2.8	5.9	0.4	3.3
13	0.6	0.3	0.6	0.0	0.5	0.5	0.4	1.6	5.7	0.5	2.8
14	1.0	0.0	1.2	0.5	1.0	0.1	0.6	0.8	5.1	0.3	2.2
15	1.2	0.3	1.5	1.4	1.5	0.5	0.4	0.3	5.2	0.0	2.3
16	1.9	0.0	2.0	1.8	1.8	0.2	0.8	0.6	4.9	0.0	2.1
17	2.4	0.1	2.5	2.0	1.8	0.0	0.8	2.0	4.1	0.3	1.7
18	2.9	0.1	3.0	1.9	2.5	0.0	0.4	2.4	3.5	0.5	1.8
19	2.6	0.2	2.6	1.9	2.1	0.6	0.3	2.6	3.5	0.3	1.5
20	2.9	0.2	2.9	2.2	2.3	1.1	1.2	3.7	3.6	0.8	1.5
21	3.2	0.8	3.4	2.6	3.6	1.1	1.9	4.5	2.3	1.7	1.4
22	2.9	1.6	3.0	2.5	3.6	1.4	3.2	5.5	0.9	2.1	1.8
23	4.2	0.5	4.4	3.0	4.4	0.4	3.4	5.9	1.0	3.1	3.5
24	5.0	0.9	5.1	3.8	4.9	0.9	4.7	6.6	0.6	2.5	4.6
25	4.9	0.3	5.0	3.6	4.4	0.5	8.1	8.6	0.8	0.9	9.5
26	5.6	0.6	5.8	4.5	4.6	0.1	9.4	9.7	2.1	2.2	11.1
27	4.7	0.3	5.0	5.0	4.2	0.1	11.2	11.6	5.3	2.6	15.0
28	3.3	1.8	3.9	3.5	3.2	1.2	15.1	14.5	8.3	2.0	26.8
29	4.7	2.1	5.2	3.3	4.5	2.1	18.3	14.9	9.7	3.9	31.6
30	7.4	1.1	7.9	4.3	7.5	1.1	21.5	14.2	11.8	4.3	40.0
AVG	2.9	1.1	3.0	2.4	2.9	1.2	4.2	5.3	4.5	1.5	6.1

Table 2: Percent differences shown for each depth on each run. Average percent difference for a specific run is shown at the bottom. Percent differences ranged from 1.1% to 5.3%.

Second Study:

- Six irradiations using either 4cm or 10cm plastic cones were measured with EBT3 film and were compared to Radiance's predicted dose (Figure 2).
- The average percent differences between all energies was 3.9% (shown in Table 3).
- In general, lower energies had smaller percent differences than larger energies.
- The smallest percent difference was shown to be 0.0%.
- The greatest percent differences was 14.2%.

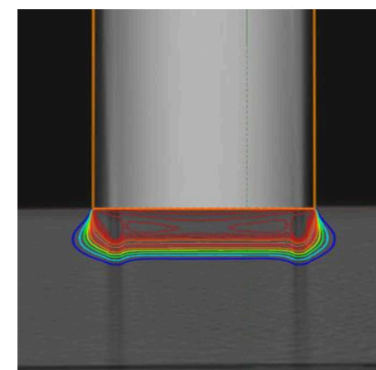


Figure 2:
Image of Radiance Treatment planning system which was used to compare between calculated and measured readings in solid water.

6 MeV	Depth (mm)	Cone Sizes (cm)					
		4			10		
		Radiance	Film	% Diff	Radiance	Film	% Diff
	11	510.0	540.9	5.7	378.6	377.9	0.2
9 MeV	17	492.6	507.4	2.9	359.9	355.1	1.4
	24	293.0	292.5	0.2	219.0	219.8	0.3
	27	183.5	171.8	6.8	141.4	130.3	8.5
	37	249.5	219.9	11.9	169.2	184.2	8.9
12 MeV	Depth (mm)	Cone Sizes (cm)					
		4			10		
		Radiance	Film	% Diff	Radiance	Film	% Diff
	20	614.2	610.7	0.6	383.8	387.7	1.0
	36	514.6	450.4	14.2	350.3	350.4	0.0

Table 3: Percent differences between film and radiance are shown for each energy and for each cone size.

CONCLUSIONS

- Radiance parameters that most closely agree with commissioning data had an average percent difference of 1.1%.
- Generally, greatest variance was shown at greater depths (>25mm).
- Average percent difference between calculated and measured doses in solid water was 3.9%.
- Percent differences generally increased at deeper depths due to comparing small values.
- The measured output factor difference between the metal and plastic cones (up to 4.8% higher for metal cones) was accounted for in the percent differences comparisons.
- Dose calculated by Radiance agreed well with measurements in solid water, however, further validation is required for more complex phantom setups.

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