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Quantifying the Energy Dependent Attenuation Differences Between H2O and RW3 Solid Water for EPID Dosimetry Deconvolution Kernel Generation

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INTRODUCTION

There has been a rise in clinical inquiries with the increasing number of EPID in-vivo commercial products in the market today. One stems from the requirement of the characterization of the EPID response to water equivalent thicknesses to account for the different thicknesses of patients under treatment. In this study we examined the signal differences of 6 MV and 15 MV beams for 3 thickness of attenuating material for 3 field sizes in water and in RW3 solid water.

BACKGROUND

With the new recommendations for EPID based in-vivo dosimetry and the increasing number of commercial EPID dosimetry systems available today, it is important to provide evaluations of the different requirements for implementation and configuration of these systems(1). One important aspect that each system shares is the need to characterize the EPID response through different thicknesses of water equivalent material. In cases where an appropriate water tank is not available for all of the measurements, it is important to know the differences in commonly available commercial solid water. Previous studies have evaluated some differences in dosimetric characteristics between various options and found that RW3 can be a good substitute for water(2). It was determined that additional investigation was warranted specifically for evaluating larger thickness and the effects on the EPID measurements. The transmission of low energy (6MV) and high energy (15MV) beams was selected to best evaluate the similarities between RW3 and water.

MATERIALS AND METHODS

Exit beam central axis signal measurements were taken with the EPID utilizing a water tank and RW3 solid water setups on the treatment couch. This was performed for 6 MV and 15 MV beams with 2x2, 10x10, and 25x25 cm field sizes. The measurements were taken with thicknesses of 10 cm, 30 cm and 45 cm. The resulting percent differences were tabulated and plotted.

RESULTS

The percent differences of the measurements between the water tank and RW3 solid water setups were mostly within 0.5 %. The largest discrepancies were found at 45 cm depths for 6 MV, where the measurements in the RW3 setup were almost 1% lower, and at 30 cm depths for 15 MV, where the measurements in the RW3 setup ranged between 0.90 - 1% higher.

DISCUSSION

The results of these investigations demonstrate that RW3 is an acceptable substitute for water when tanks of increasing dimensions are not available on-couch during transit beam EPID measurements. The differences between RW3 and water were found to be minimal, as shown in Table 1 for 6MV and Table 2 for 15MV. Figure 1 demonstrates the setup used for the measurements that closely simulates the actual measurement geometry. It is important to note that for absolute transit beam dosimetry using EPID dosimetry configurations, the attenuating material must be set up isocentrically for each thickness measured.

The imager is usually at 150-160 cm source to image distance for transit beam dosimetry. Depending on the imager, this limits the field size to a maximum of 28x28 cm at the isocenter. To provide adequate scattering material and account for the beam's divergence, the setup should include a larger base, as demonstrated in Figure 2.

To accomplish this with H_2O water, a double container setup is needed that allows gantry clearance when measuring shallower thicknesses while providing a way to measure extended thicknesses over 50 cm Figure 3 illustrates one method of achieving this setup. Conversely, the same setup can be accomplished easier utilizing different dimensions of solid water. RW3 solid water slabs are commercially available in different dimensions, including 30x30 cm slabs and 40x40 cm slabs. The setup illustrated in Figure 2 is demonstrated in the experimental setup used for this work in Figure 4.

Figure 1: Setup of measurement media for EPID characterization for each beam at different thicknesses.

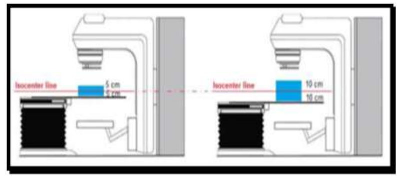

Figure 2: Utilizing RW3 solid water with 40x40 and 30x30 cm slabs to account for beam divergence.

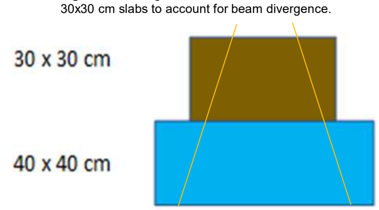

Figure 3: This image shows an H_2O setup that can measure depths beyond 40 cm. With this setup, it is possible to accurately measure the response of EPID to transit beam dosimetry at greater depths.

Figure 4: Image RW3 solid water stacked with 40x40 cm slabs for 30 cm thickness and 30x30 cm slabs for the next 30 cm of thickness

Table 1: Measurement signal comparisons between water tank phantom and RW3 solid water slabs for energy of 6 MV at various depths.

6 MV	H2O Measurement Signal			RW3 Measurement Signal			Percent Difference		
Depth	2x2	10x10	25x25	2x2	10x10	25x25	2x2	10x10	25x25
0 cm	974220	1156514	1280737	974220	1156514	1280737	N/A	N/A	N/A
10 cm	553429.3	663439.2	823398.4	556339.3	666586.5	823662.3	0.30%	0.27%	0.02%
30 cm	216985.7	274861.1	403291.5	221080.6	275928.3	405925.6	0.74%	0.16%	0.32%
45 cm	118993.8	15503	249494.8	116849.5	155390.5	246055.7	-0.99%	-0.77%	-0.85%

Table 2: Measurement signal comparisons between water tank phantom and RW3 solid water slabs for energy of 15 MV at various depths.

15 MV	H2O Measurement Signal			RW3 Measurement Signal			Percent Difference		
Depth	2x2	10x10	25x25	2x2	10x10	25x25	2x2	10x10	25x25
0 cm	865866.5	1030428	1176421	865866.5	1030428	1176421	N/A	N/A	N/A
10 cm	585746.2	727585.1	909031	590012.6	733789.8	913142.2	0.49%	0.60%	0.35%
30 cm	302460.3	396960.9	548293.2	307835.5	403494.6	557551.1	0.92%	0.90%	1.02%
45 cm	193502.4	269415.3	390549.1	193434.1	271014.1	390657.3	-0.02%	0.40%	0.02%

CONCLUSIONS

This investigation demonstrates that RW3 solid water is an acceptable substitute for water measurements for EPID exit beam characterization when a water tank setup is not available. Although water tank measurements are the most ideal, solid water includes the benefits of a reduction in setup uncertainties and reduction in setup and clean up time.

REFERENCES

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CONTACT INFORMATION

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