Validation of the Delta⁴ Dosimetry Phantom Against Ionometric Measurements

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Introduction

The semi-measured 3D dose distribution in the cylindrical Delta⁴ phantom is calculated by using the known planned dose distribution and measurement points along the two orthogonal diode planes. By taking the planned dose and measured dose from the two orthogonal detector-planes, the planned dose along each beam ray is renormalized using the ratio between the planned dose and the measured dose in the intersection point of the ray with the detector plane. The dose is then calculated along all beam rays[1]. The purpose of this study is to independently validate a point dose of the 3D dose calculation methodology used by Delta⁴ (ScandiDos AB, Uppsala, Sweden.) with a calibrated ion chamber.

Figure 1: Delta⁴ phantom
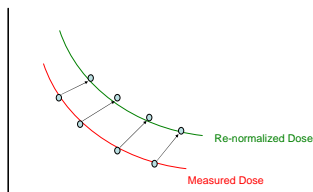

Re-normalized Dose

Measured Dose

Figure 2: Simple illustration of the 3D semi-measured dose methodology

Materials and Methods

• Measurements were performed using the TomoTherapy HiArt II system (TomoTherapy, Inc. Madison WI) and Pinnacle[3] Version 8.0m (Philips Medical, Fitchburg WI)/ Varian Clinac 2300 C/D (Varian Medical, Palo Alto CA)
• A pinpoint PTWN31006 (PTW, New York City NY) with an active volume of 0.016 cc was used for point dose measurements—see Figure 3
• Delta⁴ phantom was modified to hold the chamber in one of the four slabs—see Figure 4
• Eight Head and Neck QA plans were created in the two planning systems. Plans were scaled to vary the calculated dose to the pinpoint ion chamber

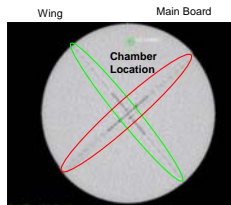**Figure 3:** Small volume PTW pinpoint PTWN31006 ion chamber

Wing | Main Board
Chamber Location
Main Board | Wing

**Figure 4:** Pinpoint location relative to the Delta⁴ phantom.

Linac Delivery

• Original plan was copied to the Delta⁴ MVCT phantom images where the chamber point was located, the coordinates identified, and the dose grid defined
• Dose at the chamber point was recorded. Dose and normal tissue contours were exported via DICOM RT to the Delta4™ software. At the moment of delivery of each plan, a point dose measurement was obtained
• Plans ranged from 20% to 160% of the prescribed dose for Pinnacle[3] in increments of 20%

Varian 2300 C/D
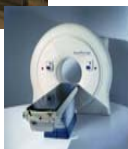
Tomotherapy HiArt
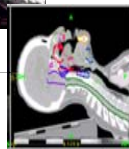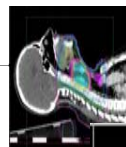
Abstract #11436

TomoTherapy Delivery

• DQA plans were created with the Delta⁴ shifted so that target volumes were placed in the center of the phantom
• Once completed, the plan, the DQA plan, the DQA dose and structures were exported via DICOM RT.
• Delta⁴ phantom was MVCT for set up accuracy. Necessary shifts were applied and
• A point dose measurement was acquired using the pinpoint chamber for each dose range and the corresponding 3D dose distribution calculated by the software. The coordinates of the pinpoint chamber were matched with those of the Delta⁴ software and a comparison of the absolute dose values was done.
• The TomoTherapy plans covered a range of doses from 20% to 100% with steps of 20% and a plan of 200% of the prescribed dose

Results

• Table 1. shows that the chamber agrees with Pinnacle[3] within 0.3% to 2%. The 20% scale dose measurement needs further investigation.
• In the other hand, the table shows that Delta⁴ overestimates the dose in all the plans while having and increasing improvement going from low doses to high doses with values ranging from -1.81% to -0.058%.
• Table 2. shows the results obtained with the tomotherapy delivery. The table shows good agreement between the chamber and the Delta⁴ system with percent values ranging from 0.03% to 5.93%. Again the plan for the 20% needs further consideration.

Table 1. Percent difference of the absolute dose measurements with Pinnacle[3] TPS, Pinpoint chamber and Delta⁴

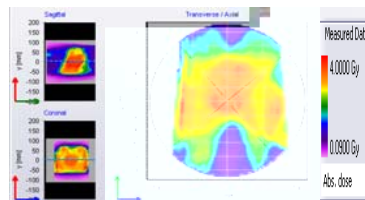| Scaled Dose	Linac Based Delivery				
(%)	Pinnacle TPS (Gy)	Ion Chamber (Gy)	Delta⁴ (Gy)	TPS and Ion Chamber Difference	TPS and Delta⁴ Difference
20	0.127	0.106	0.108	19.90%	-17.77%
40	0.254	0.267	0.259	-4.85%	-1.81%
60	0.381	0.382	0.385	-.318%	-0.909%
80	0.508	0.505	0.512	.652%	-0.644%
100	0.636	0.651	0.638	-2.31%	-0.329%
120	0.763	0.752	0.771	1.34%	-1.03%
140	0.890	0.901	0.896	-1.26%	-0.647%
160	1.017	1.025	1.018	-.780%	-0.058%

Figure 5: Screen capture of 3D dose distribution calculated by the Delta⁴ phantom

Table 2. Percent difference of the absolute dose measurements with TomoTherapy TPS, Pinpoint chamber and Delta⁴

Scaled Dose	Tomotherapy Based Delivery				
(%)	Tomotherapy TPS (Gy)	Ion Chamber (Gy)	Delta⁴ (Gy)	TPS and Ion Chamber Difference	TPS and Delta⁴ Difference
20	0.215	0.180	0.172	19.44%	25.00%
40	0.429	0.405	0.405	5.93%	5.93%
60	0.644	0.628	0.603	2.55%	6.80%
80	0.859	0.872	0.853	-1.49%	0.70%
100	1.074	1.069	1.071	0.47%	0.28%
200	2.148	2.166	2.148	-0.83%	0.00%

Conclusions

Results show good agreement among the Delta⁴ measurement, the pinpoint ion chamber measurement, and the planned dose. All high dose measurements for both TomoTherapy and Pinnacle[3] were within 2% agreement. Low dose measurements for both TPS were within +/- 4cGy. The semi-measured 3D dose calculation methodology appears to be able to accurately predict doses.

References

1. http://www.scandidos.se/?page_id=3&f=1_2_3

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