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Assessing the sensitivity for a multi-detector array for IMRT patient QA

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INTRODUCTION

Delta[4] is a 3D phantom that consists of 1069 silicon p-type diodes detectors mounted in two perpendicular planes (see figure 1). These planes are embedded in a cylindrical PMMA phantom. The sensitive volume of each of the detector planes cover an area of 200x200 mm. The resolution in the central 6x6 cm^2 area is 5mm and in outer area is 10mm. This study attempts to assess the dosimetric response of the 3D Delta[4] phantom for IMRT delivery. We specifically investigate the sensitivity of the phantom to measure dose for low, medium and high MU per beam segment and for different beam orientations.

Figure 1: Delta[4] phantom

METHOD AND MATERIALS

• Pinnacle[3] Version 8.0m (Philips Medical, Fitchburg WI) treatment planning system (TPS) was used for planning and measurements were performed using Pinnacle[3] Version with a Varian 2300 C/D linear accelerator (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 2
• Delta[4] phantom was modified to hold the chamber in one of the four slabs—see Figure 3
• Eight Head and Neck QA plans were created and scaled to vary the calculated dose to the pinpoint ion chamber.

Figure 2: Small volume PTW pinpoint PTWN31006 ion chamber

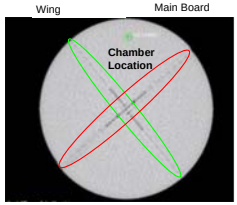


Figure 3: Pinpoint location relative to the Delta[4] phantom.

• The original plan was copied to the Delta[4] MVCT phantom images where the chamber point was located, the coordinates identified, and the dose grid defined
• In the TPS the 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.
• The same plans were delivered using all the beams at only one gantry angle (180º degrees).
• Plans ranged from 20% to 160% of the prescribed dose in Pinnacle[3] in increments of 20%
• To assess the response of the Delta[4] detectors to the various scaled doses, an evaluation of the planned versus delivered dose distributions using gamma index analysis and dose profiles was done.

RESULTS

Table 1. shows a very good agreement between planned and detector measured dose for each step dose . Using a DTA/dose difference tolerance of 3mm/3% for the gamma index analysis (see Figure 4), the percentage of voxels satisfying this criterion were higher than 95% for the dose range in both cases. Good agreement can be seen in the profiles as well (see figure 5). The point measurement dosimetry with the pinpoint chamber showed, in average, a lower discrepancy than 2% against the treatment plan for multi-angle and single angle delivery (Table 2).

	160%	140%	120%	100%	80%	60%	40%
Whole plan	99.0	99.3	99.2	98.8	97.5	95.4	71.9
Single gantry angle	100	100	100	100	99.4	99.9	97.9

Table 1. Gamma Analisys: Value in % of Gamma Index<1 with DTA/Dose difference of 3mm/3%

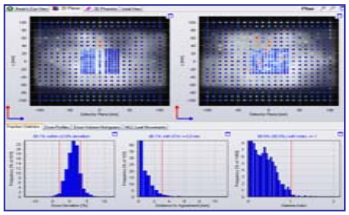


Figure 4. Gamma analysis for a specific plan using a tolerance of 3mm/3%

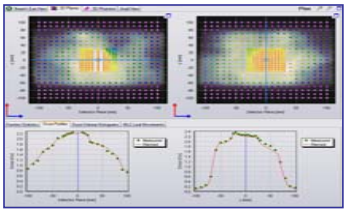
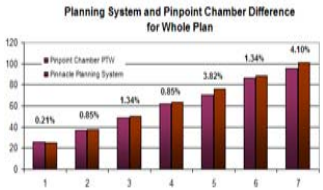


Figure 5. Profile analysis (Left: Horizontal profile, Right: Vertical profile) for a specific plan



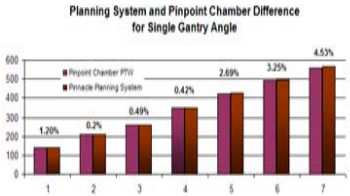


Table 2. Percent difference between the PinPoint chamber measurement and the plan dose for the two types of delivery. Left: Original plan. Right: All beams at 180º degrees

CONCLUSIONS

The measurements were in agreement with the planned dose for the plans that were scaled at 100% of the prescribed dose or higher. In the cases where low number of MUs per segment was used (40% scaled dose) the agreement was lower than 80%. The planned dose distribution compared to the measurement improves when all the beams are delivered from the 180º angle (Varian convention). Overall, this study indicates a very good response of the array detectors for a wide range of dose around the therapeutic dose use in IMRT treatments.

REFERENCES

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