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On the feasibility of angle-resolved portal dosimetry for patient specific quality assurance of VMAT plans

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INTRODUCTION

AAPM Task Group 218[1] recommends against the use of portal dosimetry for VMAT quality assurance because variations from the planned dose rate or gantry position can be masked within the integrated images.

The purpose of this work was to investigate the feasibility of splitting VMAT plans into angular segments to better detect and quantify potential plan errors. This poster presents initial results of a detailed study of this phenomenon.

METHODS

VMAT plans were anonymized and a commercial treatment planning system was used to divide full arc plans into segments of 5°, 10°, 20°, 45°, and 180°.

Python scripts were used to stitch segments together into one plan and add the associated imaging information for automatic delivery of all segments within Developer mode on a Varian TrueBeam. This allowed for all segments to be delivered within the same amount of time as standard portal dosimetry plans

EPID linearity, MLC positioning errors, imager positioning errors, and output errors were simulated by introducing errors into anonymized plans.

Angle resolved plans were compared to full-arc measurements using portal dosimetry and a cylindrical diode array phantom.

Portal dosimetry measurements were analyzed using a gamma-index with 3%/2 mm 1 cm MLC CIAO, while phantom measurements were assessed using 3%/2 mm 10% threshold.

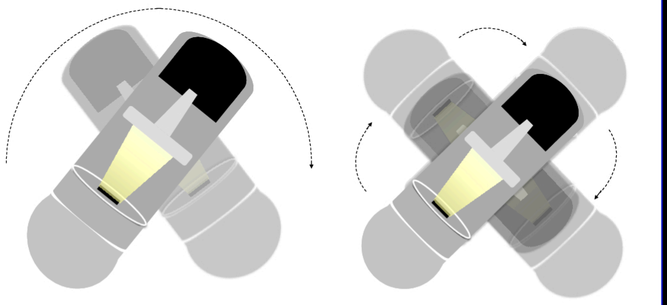

Figure 1: Illustration of standard portal dosimetry (left) and the method used for angle resolved portal dosimetry (right).

RESULTS

EPID linearity was tested using a 10×10 cm^2 field with dose deliveries ranging from 100 to 1 cGy. Predicted and delivered doses were within 4% for doses down to 1 cGy.

In the initial test of this method, 63% of segments failed for divisions up to 90°. Dummy control points were inserted between segments to ensure proper image acquisition, resulting in all segments ≥ 90° passing.

After the addition of dummy control points, standard VMAT plans showed 42% of segments failing with divisions ≤ 45°, while SBRT plans showed failures at 5° only (Table 1). Passing results for composite images (summed over all segments) matched passing results for standard portal and phantom measurements (Figure 2).

To ensure imager shift/sag was not causing these failures, plans were re-delivered at a fixed gantry angle of 180°. These results were consistent with arc delivery.

MLC errors of 1, 2, or 5 mm were manually inserted into plans. Errors of 1 mm and 2 mm had no impact on passing rates, whereas errors of 5 mm showed large failures.

Dose errors of 1-5% were inserted into plans and compared to nominal segment dose distributions. Errors of 1-2% did not impact passing rates, while some failures were noted for errors of 3%. Large failure rates were observed with errors of 4-5% (Figure 3).

Table 1: Percentage of segment failures for each patient plan based on segment angle.

Angle	H&N VMAT	Lung VMAT	Lung SBRT
5°	59.70%	25.50%	1.40%
10°	50.00%	22.20%	0.00%
20°	37.00%	11.50%	0.00%
45°	16.70%	0.00%	0.00%
90°/180°	0.00%	0.00%	0.00%

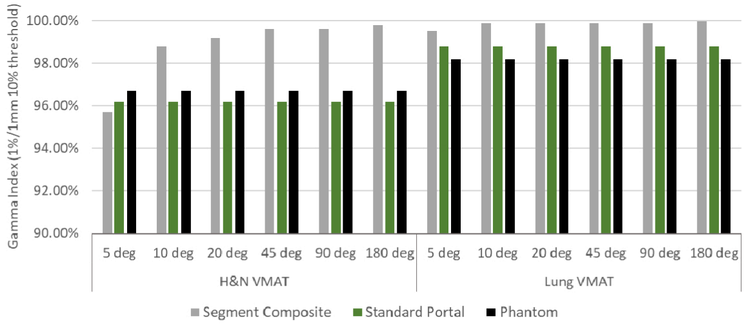

Figure 2: Comparison of gamma passing rates between segment composite images, standard portal dosimetry, and phantom measurements. Composite segment images were compared to the standard portal dosimetry delivery. A gamma index of 1%/1mm 10% threshold was used to illustrate the small differences between planes.

Figure 3: Illustration of the changes in passing rate for one 5° segment for various output errors from 1% (left), to 3% (middle), to 5% (right).

CONCLUSIONS

Gamma-index failure rates increased with decreasing arc-segment size in angle-resolved portal dosimetry of VMAT plans, despite consistent results between composite segment images and standard portal dosimetry/phantom measurements.

Testing ruled out a significant impact of MLC errors and imager shift/sag on gamma passing rates.

Based on SBRT results and dose error analysis, small errors in dose delivery appear to lead to large gamma errors when small doses are delivered. Further investigation is needed to quantify the nature and impact of the observed discrepancies, as well as the feasibility of angle-resolved portal dosimetry for VMAT QA.

REFERENCES

[1]Miften, M. *et al*, "Tolerance limits and methodologies for IMRT measurement-based verification QA: Recommendations of AAPM Task Group No. 218". Med Phys, 45(4) e53-e83, 2018.

CONTACT INFORMATION

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