Linac-based SBRT delivery QA and decreased gamma criteria

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INTRODUCTION

The AAPM TG-218 report recommends gamma criteria (Y) percent dose (%) and distance to agreement (DTA), to be evaluated at 3%, 2mm at a dose threshold of 10% and an action limit (AL) of 90%. They suggest that these criteria be lowered further for modalities such as SBRT. Given the small target size and non-homogenous dose distributions commonly associated with SBRT, our hypothesis was that we would see increasing failure as a function of decreasing PTV diameter.

AIM

To evaluate the efficacy of delivery error detection for linac-based SBRT following AAPM TG-218 recommended tolerances and gamma criteria reductions.

METHOD

Patient-specific ionchamber array-based delivery QA analysis for 75 previously treated VMAT patients analyzed at 3%, 3mm and a threshold of 10% was repeated with gamma criteria of 2%, 2mm and a threshold of 50%. A universal action limit (AL) of 90% was used and results were plotted as a function of equivalent PTV diameter. Regions of failure were geometrically correlated between the phantom and the planning CT data set and planned values were adjusted based on delivery results to assess the likelihood of treatment start delay.

RESULTS

PTV diameter ranged from 2.0cm-5.6cm. A negative low correlation (r = -0.31) was found for 38 of 75 cases below the AL with an approximate change in passing rate of 5.3% over this range. 35 cases failing the AL had values within the PTV region resulting in doses greater than the prescription dose but less than the target maximum. 20 of these cases were evaluated at 2 separate points of maximum deviation. 3 cases exceeded the target maximum by between 0.6% and 2.1%. 7 cases failed outside the PTV with 4 resulting in lower than predicted doses. 3 cases outside the PTV resulted in higher than predicted dose by a maximum of 20.2%.
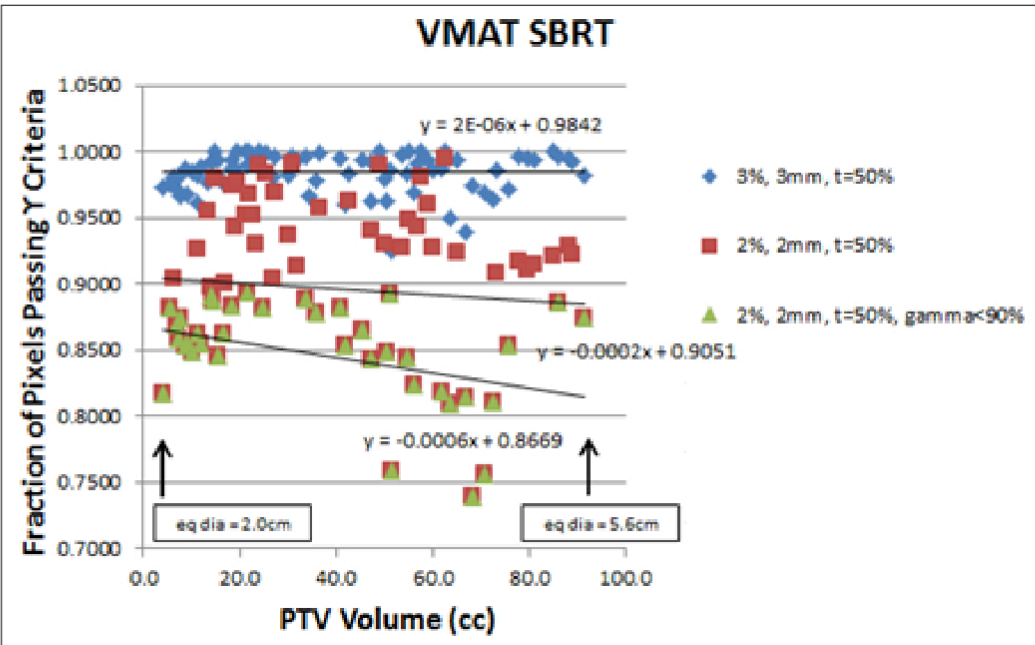

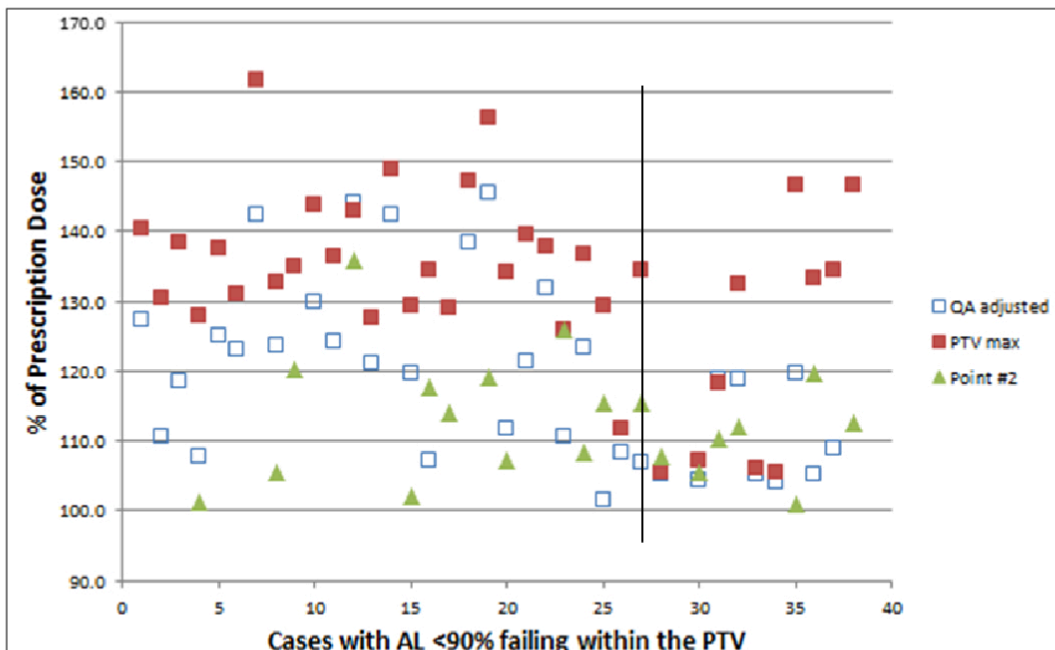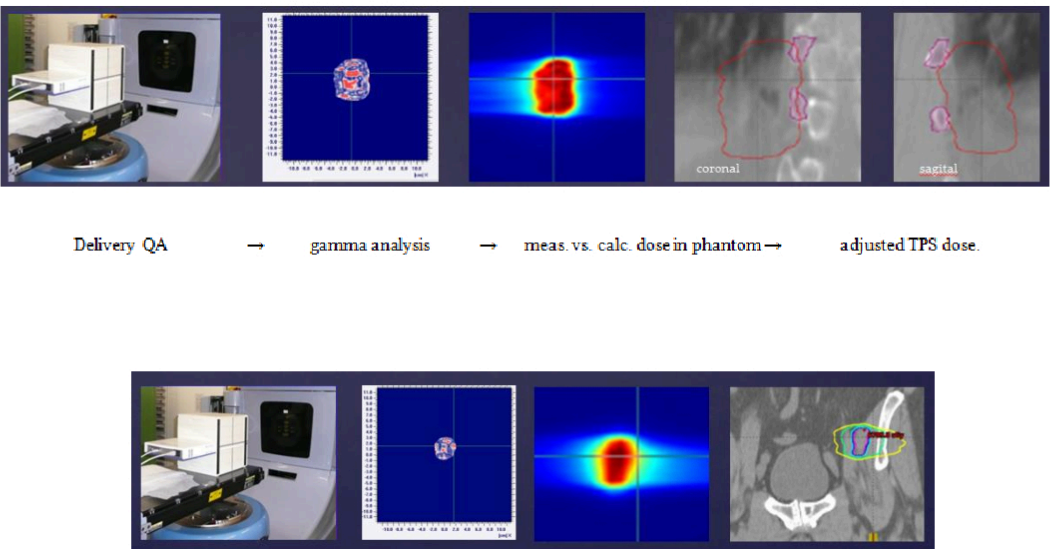Figure 1. Passing rate as a function of size (2%, 2mm DTA, t = 10%).

Figure 2. Failing AL within the PTV (top); failing AL outside the PTV (bottom).

Figure 3. Clinical significance of failures within the PTV. Individual cases read from top to bottom.
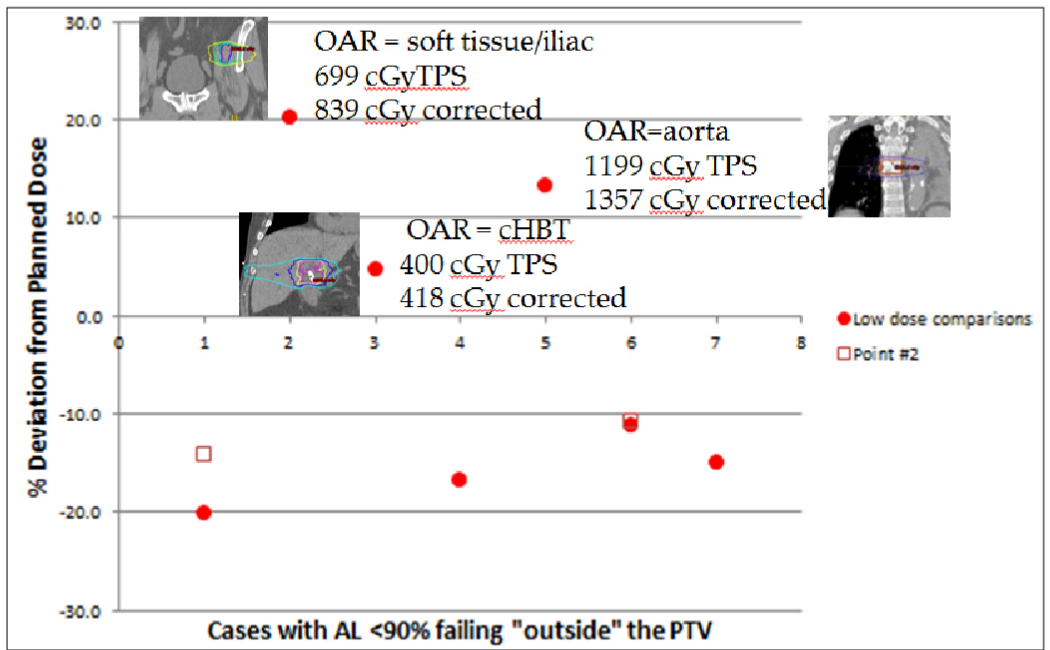

Figure 4. Clinical significance of failures outside the PTV.

CONCLUSIONS

Following evaluation, no case would have been delayed for gamma failure within the target region nor outside the PTV. Variance resulting in higher than predicted dose outside the target was found to be acceptable in all 3 cases. It was found that array-based SBRT delivery QA results do not strongly correlate with target size over the range studied. Additionally, the TG-218 suggested decreased gamma criteria may not strongly predict clinically meaningful delivery errors.

REFERENCES

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), April 2018, e53-83.

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