Sensitivity of detecting MLC positioning errors for SBRT treatment at Halcyon Linac

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INTRODUCTION

- Varian's new Halcyon Linac is unique in that it uses two sets of stacked and staggered MLCs rather than standard MLCs with no jaws.[1]
- SBRT prostate treatments deliver high doses of radiation to the prostate while sparing normal tissues using steep dose gradients outside of the target.[2]
- Errors in MLC leaf positioning can compromise the target coverage as well as the normal tissue sparing.[3]
- Varieties of quality assurance (QA) devices are available in the clinic for verification of the SBRT plans.

AIM

- To investigate which quality assurance procedure is the most sensitive to detect potential leaf positioning errors for prostate SBRT treatments on the Varian Halcyon Linac.

METHOD

- To replicate a potential MLC positioning error, two prostate SBRT plans (using 6MV-FFF beam, 2 full arcs VMAT treatments for a total prescription dose of 36.25 Gy in 5 fractions) were used.
- The position of one MLC used to modulate dose in the center of the target volume was offset by a predetermined distance for each control point.
- The MLC offsets being simulated were 1-mm, 2-mm, and 3-mm, systematically.
- QA plans were created and delivered on the Halcyon Linac using either portal dosimetry (PD), ArcCHECK, or PTW Octavius QA devices.
- The composite distribution was evaluated using the clinical gamma criteria of 2%/2mm, with ≥ 90% pass rates.

RESULTS

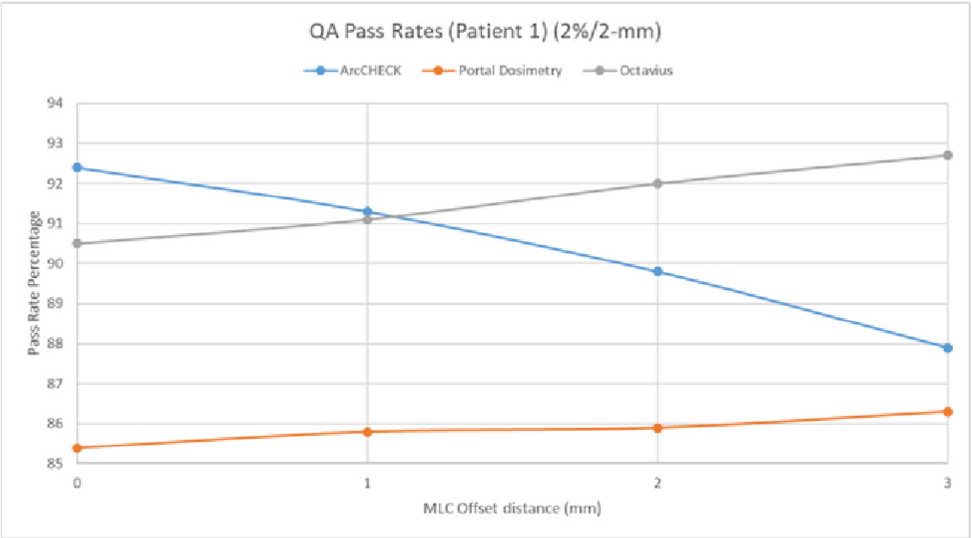

Figure 1. QA pass rate for composite distribution of prostate SBRT patient #1 evaluated for 2%/2-mm gamma passing criteria. In this case, ArcCHECK was able to detect MLC errors with 2 and 3 mm offsets with < 90% pass rates (see blue curve)

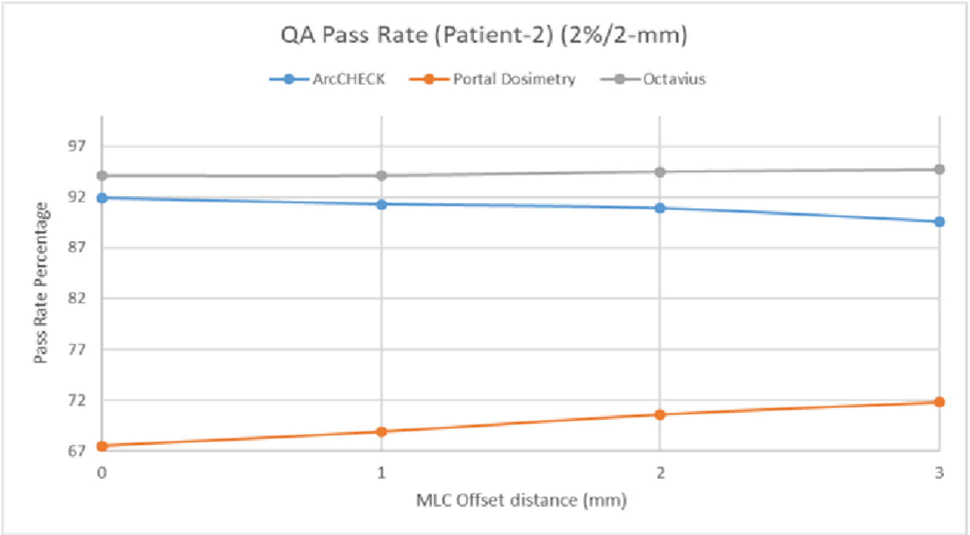

Figure 2. QA pass rate for composite distribution of prostate SBRT patient #2 evaluated for 2%/2-mm gamma passing criteria. Here also, ArcCHECK shows some trend of detecting MLC errors compared to other 2-devices.

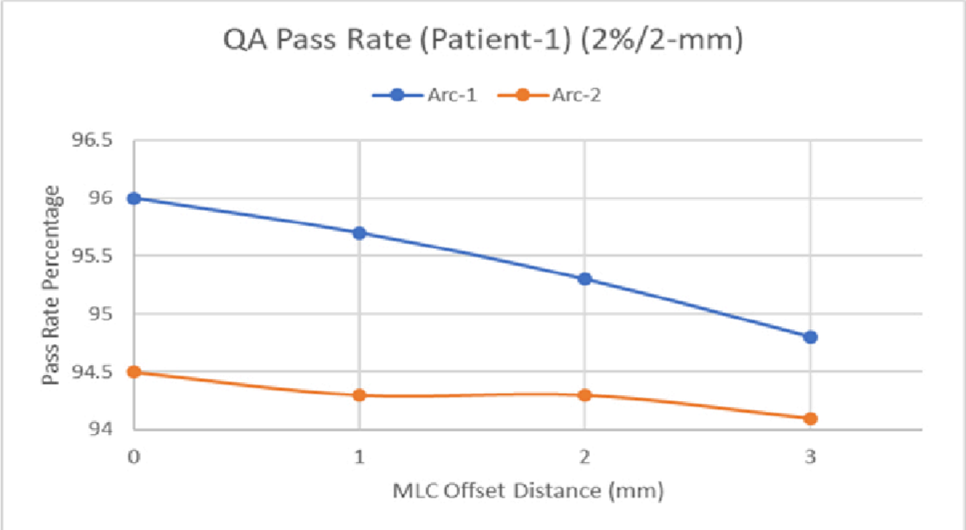

Figure 3. QA pass rate for portal dosimetry field by field comparison of prostate SBRT patient #1 evaluated for 2%/2-mm gamma passing criteria.

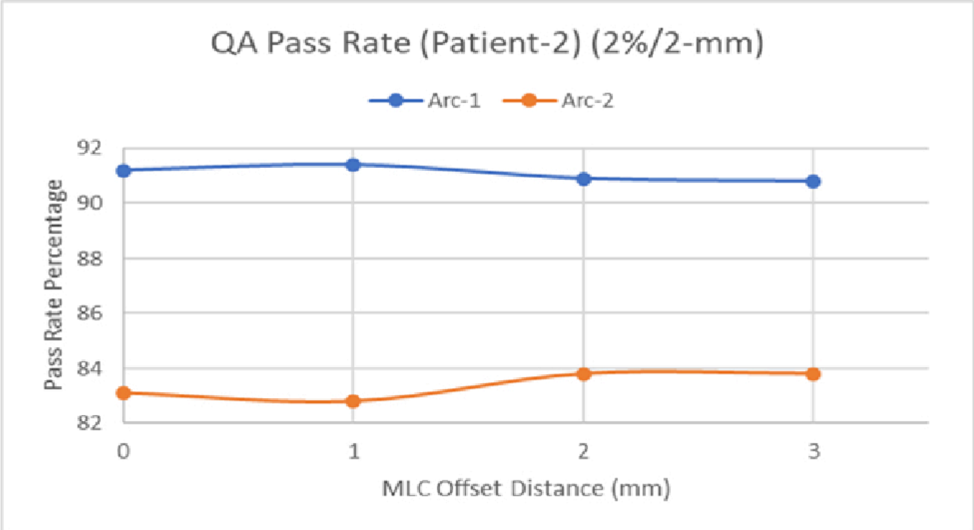

Figure 4. QA pass rate for portal dosimetry field by field comparison of prostate SBRT patient #2 evaluated for 2%/2-mm gamma passing criteria

SUMMARY / CONCLUSIONS

- Current data evaluating the composite distribution for both patients showed an expected trend of decreasing pass rates with increasing MLC offsets detected by Sun Nuclear ArcCHECK device.
- Both portal dosimetry and PTW Octavius failed to exhibit this trend.
- This result has prompted investigation into the underlying cause for the failure of PD and Octavius device to exhibit the expected trend and also an evaluation of the distributions on a field-by-field basis, which is currently ongoing.
- Future work involves repeating this experiment on a Varian Truebeam Linac to determine if the standard millennium MLC positioning errors can be detected ahead of time for a single-fraction (30 Gy or 34 Gy in 1 fraction) lung SBRT patients.

ACKNOWLEDGEMENTS

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REFERENCES

1. Varian Halcyon V2.0 User's Manual (2019)

2. NRG-RTOG 0938 Prostate SBRT Protocol (2015)

3. Miften, M, Olch, A, Mihailidis, D. et al. Tolerance limits and methodologies for IMRT measurement-based verification QA : *Recommendations of AAPM Task Group No. 218* . Med. Phys., (2018) 45: e53-e83.

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