Error Detection Sensitivity of the SNC and PTW Patient-Specific Quality assurance Devices

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INTRODUCTION

The high complexity of IMRT planning, dose calculation and treatment delivery requires careful quality assurance which is most commonly performed with patient specific end-to-end tests using 2D and 3D detector arrays. The vendors SNC and PTW are some of the largest providers for dosimetry equipment including various types of patient specific quality assurance (PSQA) devices. The 2D arrays, the PTW Octavius 1500 and SNC MapCheck, have similar detector density on the array but the PTW model uses 1405 plane-parallel vented ionization chambers, whereas the slightly larger SNC array consists of 1527 diodes. The Octavius 1500 can be inserted into a 4D phantom that aligns the 2D array perpendicular to the rotating gantry to measure VMAT plans. SNC offers a separate device for 3D VMAT QA, the ArcCheck, where the diode array is "wrapped" around a cylindrical phantom.

AIM

The authors compare detection sensitivities for dosimetric errors of four competing IMRT and VMAT PSQA devices.

METHOD

Verification plans for 24 IMRT and 21 VMAT treatments were projected on solid water phantoms and the RT-dose was exported in 5cm depth. The X-ray energy was 6MV, which is most often used for IMRT, and 10MV, which was being commissioned for clinical use at the time of the measurements. This commissioning included the optimization of MLC transmission and dosimetric leaf gap (DLG) settings based on IMRT passing rates and eight plans have been used for the SNC-PTW comparison. The treatment plans covered a wide range of sites including highly modulated H&N and homogeneous breast-tangents plans. Additionally, two sets of treatment plans for IMRT and VMAT with MLC position-errors were created.

The IMRT plans were measured with the SNC-MapCheck and the PTW-Octavius 1500 on a Varian Truebeam. VMAT plans were recorded with the SNC-ArcCheck and the PTW-Octavius4D. The gamma value based on absolute dose with 10% threshold was used to quantify the passing-rate for passing-criteria of 3%/3mm down to 1%/1mm as suggested by TG218[1]. The gamma value was calculated in 2D for IMRT in SNC-Patient and PTW-Verisoft; and in 3D for VMAT in SNC-3DVH and PTW-Verisoft.

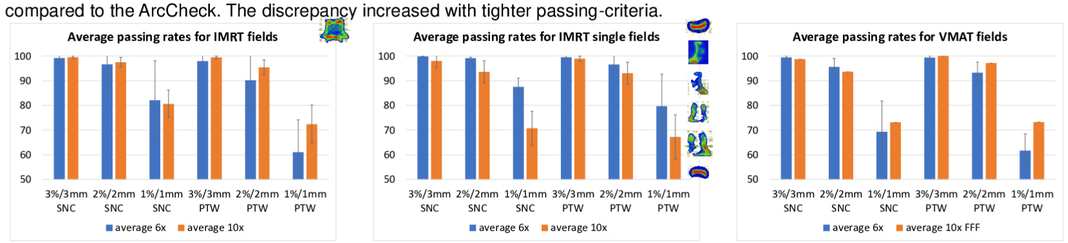
PTW Octavius 1500 and Octavius 4D

SNC MapCheck 2 and ArcCheck

RESULTS

Patient-specific QA

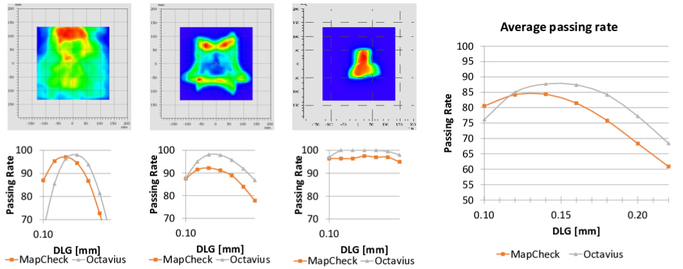
The average passing rate was lower for Octavius1500 than MapCheck at 6MV and slightly lower at 10MV and for the Octavius4D compared to the ArcCheck. The discrepancy increased with tighter passing-criteria.



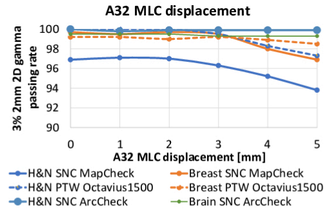
Average passing rates for SNC Mapcheck and PTW Octavius 1500 for composite fields and single fields, and for the SNC ArcCheck and PTW Octavius 4D

DLG optimization

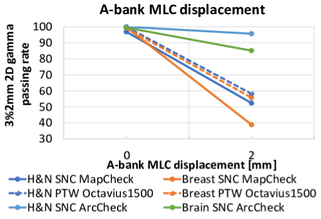
The screenshots of treatment fields along with passing rates as a function of DLG show that large, heavily modulated treatment fields are very sensitive to the DLG settings whereas passing rates for small, homogeneous fields are almost independent of the DLG. MapCheck and Octavius 1500 are equality sensitive to changes in the DLG, but the Octavius data peak at a by 0.2mm larger DLG than the MapCheck data.



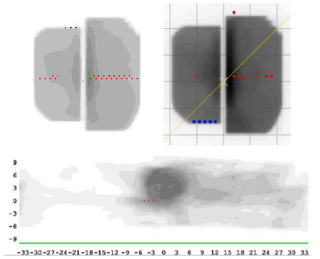
Manually introduced MLC shifts



Passing rate as a function of single MLC displacement: All but the H&N plan with 5mm MLC shift measured with MapCheck pass the TG218 universal tolerance limit of 95% with 3%/2mm and 10% dose threshold.



Passing rate as a function of MLC bank displacement: Only the H&N plan measured with ArcCheck passes the 95% limit. IMRT plans pass with less than 60%.



Failing pixels (in red) for a 5mm MLC shift in the breast plan measured with MapCheck (left) and Octavius 1500 (right) and in the brain plan measured with ArcCheck.

DISCUSSION

Patient specific quality assurance is a key component of intensity modulated radiation therapy. The passing rate is generally high for all four devices and only one IMRT and one VMAT plan were below the TG218 tolerance limit of 95% and none was below the action limit of 90%. Factors that have impact on the slightly smaller passing rate for the Octavius measurements are the detector sensitivity, the build-up material, and interpolations and uncertainties used in the detector array gamma-analysis.

Both IMRT detectors are suitable for DLG optimization. The optimum DLG differs by 0.02mm, but the passing rate only changes by less than 2% in average within a shift of ±0.02mm in the DLG.

For the 3%/2mm criterion, passing rates for VMAT plans are unchanged for single MLC shifts up to 5mm and only decrease by a maximum of 3% for 5mm shifts in IMRT plans. The position of failing pixels, however, indicates the failure of a single MLC despite a passing rate of >95%. A shift of the full MLC-bank by 2mm reduces the passing rate in average by 15% for VMAT and 47% for IMRT which is significant larger than previously reported for ClinaciX[2] and Trilogy[3] linacs.

CONCLUSIONS

The passing rate for PSQA with the PTW devices is slightly lower. Octavius 1500 and MapCheck are both suitable for DLG optimization. PSQA on IMRT plans is more sensitive to shifts in MLC positions than for VMAT plans.

ACKNOWLEDGEMENTS

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