

Evaluation of a Diode Array for Patient Specific QA of An Automated VMAT SRS System

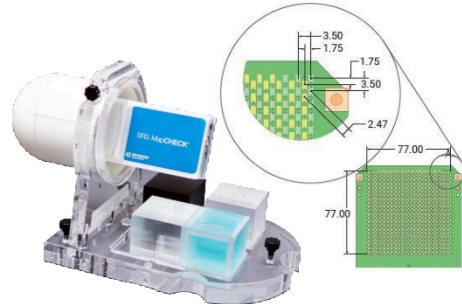
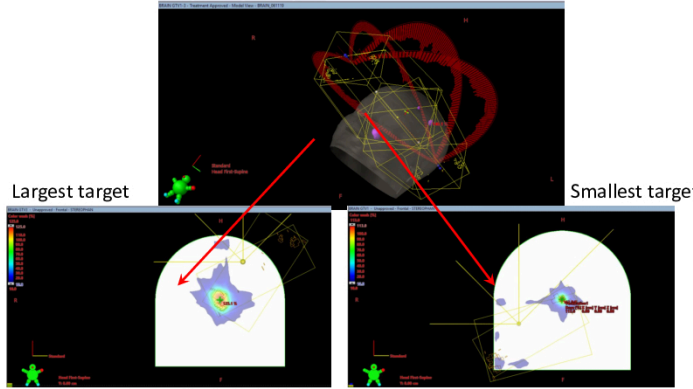
R Popple, R Sullivan, Y Yuan, and X Wu

The University of Alabama at Birmingham, Birmingham, AL

QUICK SUMMARY

- The SRS MapCHECK (Sun Nuclear Corporation, Melbourne, FL), 2-dimensional diode array, was compared with radiochromic film (RCF) for patient-specific quality assurance (PSQA) of VMAT SRS planned using HyperArc™ (Varian Medical Systems, Palo Alto, CA)
- The average difference between the center diode and RCF was -1.2%.
- No dependence on target size was observed.
- The gamma pass rate was consistent between 2DA and RCF.
- The 2-dimensional array is a suitable replacement for radiochromic film for PSQA of VMAT SRS.

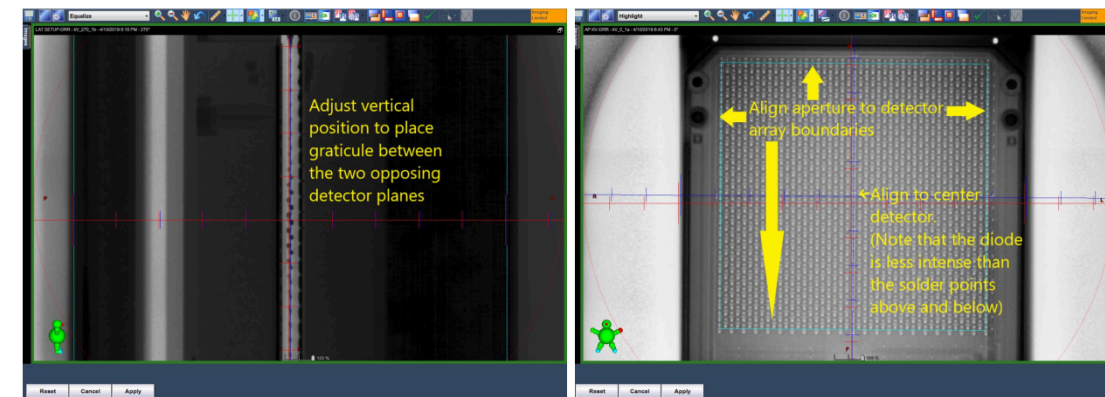
METHOD

- The SRS MapCHECK (Sun Nuclear Corporation, Melbourne, FL) is a two-dimensional diode array comprised of 1013 diodes arranged in a 77x77 mm² face-centered array of 1013 diodes. Each diode is spaced 2.47 mm from its 4 nearest neighbors. The array is inserted into the StereoPHAN (Sun Nuclear Corporation, Melbourne, FL), a 15.2 cm diameter cylindrical acrylic phantom with a hemispherical end cap.
 
- HyperArc™ is a semi-automated planning and delivery system for stereotactic radiosurgery (SRS) using volumetric modulated arc therapy (VMAT). HyperArc™ plans can include non-coplanar beams at table angles 45, 90, 270, and 315 degrees (IEC coordinate system).
- Sixty HyperArc™ plans, 30 having multiple targets, were selected from our PSQA database. The plans used a 10MV flattening-filter-free beam of an Edge linear accelerator (Varian Medical Systems).
- The PSQA used radiochromic film (RCF) (EBT-XD, Ashland Global Holdings Inc., Wilmington, Delaware) in an acrylic phantom. A calibration curve was established for each measurement session using a standard MLC pattern. For multi-target plans, measurements were done for the smallest and largest targets.
- The PSQA measurements were repeated using the SRS MapCHECK. The isocenter of the patient plan was placed in the phantom such that the center of the target of interest (either the largest or smallest target) was located at the center detector of the diode array. Prior to measurement, a dose calibration was done using a 4 cm x 4 cm field was done and the SRS MapCHECK was positioned using image guidance. For each measurement, the phantom was shifted according to the verification plan using automated couch movement available at the linear accelerator control console.
 

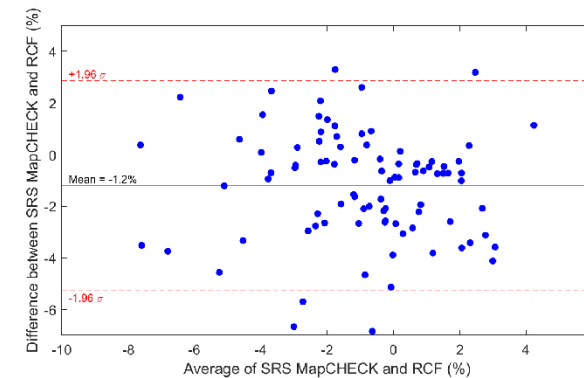
- The dose reported by the center diode was compared with the corresponding RCF location.
- Gamma was calculated using 3%/2mm criteria.

RESULTS

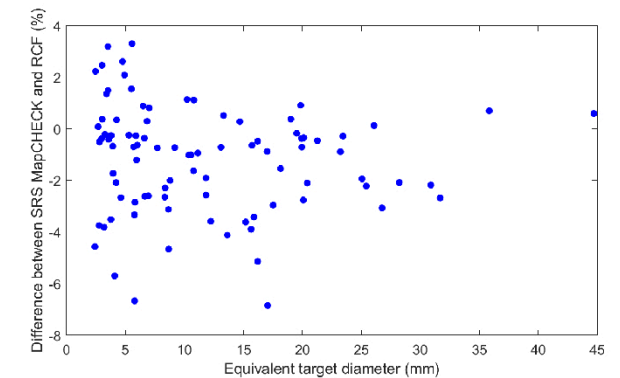
Example of image guided phantom setup using orthogonal kV images. At the start of a measurement session, AP and lateral views were acquired using the on-board kilovoltage imaging system and the position was adjusted using the detector plane, the edge rows and columns of the array, and the location of the central (CAX) diode.



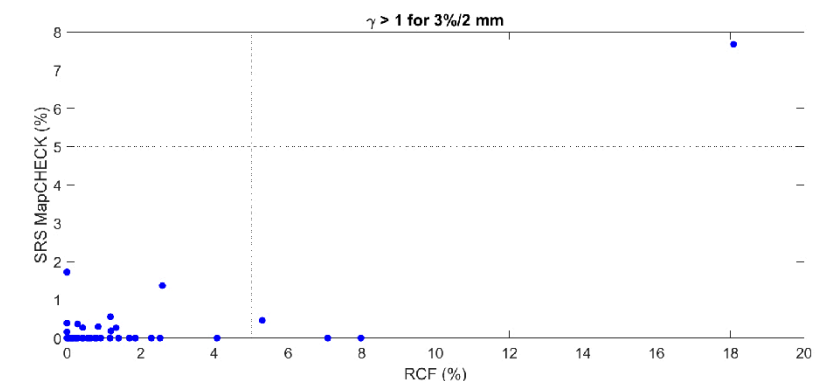
Bland-Altman plot comparing the CAX diode with RCF. The mean difference between the CAX diode and the average was -1.2%.



Difference between CAX diode and RCF vs. equivalent target diameter. The equivalent target diameter is the diameter of a sphere having the same volume as the target of interest. Note that there is not a significant correlation between the difference and the equivalent target diameter, indicating that the response of the SRS MapCHECK is independent of target size.



Clinical decision making using the gamma index is based on the number of pixels/detectors having a gamma index ≤ 1 . The tolerance limit recommended by the AAPM task group 218 is gamma passing rate $\geq 95\%$ with 3%/2 mm and a 10% dose threshold. A comparison between the gamma pass rates for SRS MapCHECK and RCF is shown in the figure to the right. Evaluation of the three plans that met the TG-218 tolerance for SRS MapCHECK but not for RCF suggested that the difference was due to two effects. First, the 1.1% difference between SRS MapCHECK and film resulted in diodes having gamma < 1 for which gamma would be > 1 if the dose was increased by 1.1%. Second, the three plans were for large targets and the variation in RCF response resulted in regional variations in gamma.



CONCLUSIONS

The SRS MapCHECK is a suitable replacement for RCF for VMAT SRS. Further investigation is underway to identify the small systematic difference between the center diode and RCF.

ACKNOWLEDGEMENTS

This work was supported by a grant from Sun Nuclear Corporation.