# Commissioning of SRS MapCHECK for CyberKnife MLC Patient-Specific QA

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## ABSTRACT

**Purpose**
To commission the SRS MapCHECK detector for patient-specific quality assurance (PSQA) of CyberKnife multileaf collimator (MLC) treatment plans and to evaluate its clinical performance across multiple disease sites using stringent gamma analysis criteria.
**Methods**
An SRS MapCHECK detector (77 mm × 77 mm) mounted in the StereoPhan was scanned on a CT simulator with 1-mm slice thickness in two orientations (0° and 90°). The StereoPhan density was overridden to 1.20 g/cm³ in the Precision Treatment Planning System. A calibration plan was generated using the CyberKnife MLC with a 10 × 10 cm² field size and 100 MU delivered to the detector plane. The delivered dose, determined by averaging five dose points, was used to calibrate the SRS MapCHECK.
Two patient QA templates were created from the 0° and 90° StereoPhan CT datasets. Embedded SRS MapCHECK fiducials were used for phantom setup and alignment. These templates were fused with approved patient treatment plans to generate patient-specific QA plans. QA plans were registered to the phantom geometry and optimized by aligning the 50% isodose line within the active detector area. Manual phantom isocenter adjustments were performed to maximize detector coverage, particularly for targets with significant longitudinal variation. Patient-specific QA measurements were evaluated using gamma analysis with criteria of 3%/1 mm and a 10% dose threshold.
**Results**
The commissioned SRS MapCHECK system was used to evaluate 113 CyberKnife MLC treatment plans, including 27 spine, 42 prostate, 33 brain, 6 lung, and 5 abdominopelvic cases. All plans achieved gamma passing rates greater than 95% using the 3%/1 mm criteria. Dual StereoPhan orientations and manual registration adjustments improved detector coverage across a wide range of target sizes and anatomical sites.
**Conclusion**
SRS MapCHECK was successfully commissioned for CyberKnife MLC patient-specific QA using stringent gamma criteria. The system demonstrated reliable performance across multiple treatment sites, supporting its clinical use for high-precision CyberKnife treatments.

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## INTRODUCTION

The newer Cyberknife Robotic Radiosurgery System (Accuray, Madison, WI) such as M6/S7 is equipped with Multileaf Collimator (MLC), therefore can significantly reduce the treatment time and effectively target large or irregularly shaped tumors (Compared to traditional circular collimators). As an SRS/SBRT plan, it requires the patient QA to be conducted before the first fraction if using MLC in any field.

SRS MapCHECK diode array in the StereoPhan phantom (Sun Nuclear Corporation, Melbourne, FL) is a reliable tool for SBRT/SRS QA to be in compliant with TG101. It is equipped with 1,013 *SunPoint2* diode detectors, providing a 7.7 x 7.7 cm² field size and a 0.48 mm x 0.48 mm active area in each diode. The StereoPhan is a phantom made with polymethyl methacrylate and designed for streamlining stereotactic end-to-end testing and QA.

This project is to commission the SRS MapCHECK for patient-specific quality assurance (PSQA) for CyberKnife MLC treatment plans as well as to evaluate its clinical performance across multiple tumor sites using stringent gamma analysis criteria.

## METHODS AND MATERIALS

An SRS MapCHECK detector was mounted in the StereoPhan. The entire set was scanned on a CT simulator with 1-mm slice thickness in two orientations: 0° and 90°. The StereoPhan density was later overridden to 1.20 g/cm³ in the Precision Treatment Planning System (Accuray, Madison, WI). Using the CyberKnife MLC with a 10 × 10 cm² field size, a calibration plan was generated with 100 MU delivered to the detector plane. The delivered dose (determined by averaging five dose points) was used to calibrate the SRS MapCHECK.

Two patient QA templates were created for 0° and 90° StereoPhan CT datasets. SRS MapCHECK fiducials (embedded) were used for phantom setup and alignment. The templates were fused with approved patient treatment plans to generate PSQA plans, which were registered to the phantom geometry and optimized by aligning the 50% isodose line within the active detector area. Manual phantom isocenter adjustments were performed to maximize detector coverage, particularly for the targets with significant longitudinal variation.

The PSQA measurements were evaluated using gamma analysis (3%/1 mm and a 10% dose threshold).

**Figure 1.** Setup of an SRS MapCHECK with the StereoPhan phantom

## RESULTS

The array calibration and dose calibration were carefully performed. An end-to-end test was also completed. After the successful commissioning of the SRS MapCHECK system, it was evaluated with 113 CyberKnife MLC treatment plans: 27 spine, 42 prostate, 33 brain, 6 lung, and 5 abdominopelvic cases.

Figure 1 shows the setup of the SRS MapCHECK on the treatment couch of a Cyberknife M6 system. Figure 2 shows an example of how the 50% isodose line extends beyond the active detector area. The ideal QA plan should include the 50% isodose line within the detector in all directions, to verify the steep drop-off outside the tumor target. Figure 3 presents the use of a 90° StereoPhan orientation, which provides improved coverage of the 50% isodose line within the detector. In Figure 4, the phantom was shifted toward the prostate apex and improved the alignment of the 50% isodose line within the active detector area.

Using the 3%/1 mm gamma criteria, all plans achieved a passing rates greater than 95%. It is noticeably that dual StereoPhan orientations and manual registration adjustments improved detector coverage across a wide range of target sizes and anatomical sites.

Figure 5 shows an example of comparison between measured and calculated dose distributions with a 100% agreement.

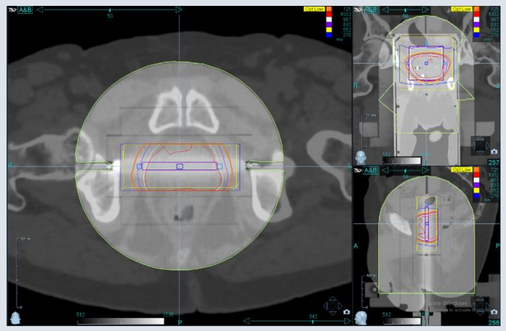

**Figure 2.** The 50% isodose line extends beyond the active detector area.

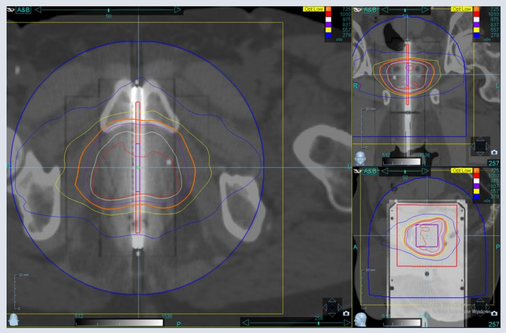

**Figure 3.** 90° StereoPhan used to improve the coverage of 50% isodose line.

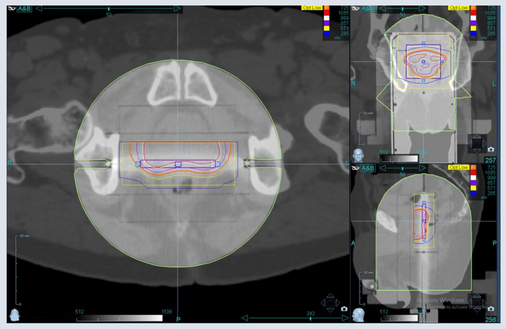

**Figure 4.** A shifted phantom towards the prostate apex to include the 50% isodose line within the detector area .

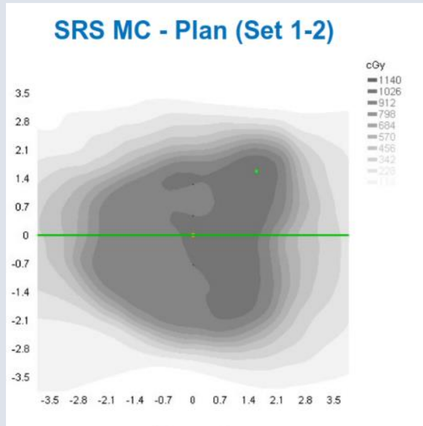


**Figure 5.** A comparison between measured and calculated dose distribution with 100% agreement (3%/1mm)

## DISCUSSION

In addition to the PSQA for SRS/SBRT, SRS MapCHECK is also capable to conduct machine QAs for Cyberknife including MLC QA, Iris Beam QA, and Targeting Accuracy QA (TAQA). MLC QA is performed with a film-less Garden Fence test: the software measures positional offsets for 52 leaves at 5 different positions. As shown in Figure 6, the Iris Beam QA can evaluate Iris collimator diameters to verify the aperture size constancy. The TAQA can be used to replace the traditional film-based daily targeting accuracy tests, which makes SRS MapCHECK very versatile on Cyberknife related QA tasks.

| D10 mm | Current | Baseline | Difference | Alert | Error | Pass/Fail |
|---|---|---|---|---|---|---|
| Diameter (mm) | 9.34 | 9.40 | -0.06 | 0.50 | 1.00 | Pass |
| Diam Max-Min (mm) | 0.30 | 0.26 | 0.04 | 0.17 | 0.29 | Pass |
| Penumbra (mm) | 3.02 | 2.94 | 0.09 | 0.15 | 0.29 | Pass |
| Flatness (Area)(%) | N/A | N/A | N/A | N/A | N/A | N/A |
| Symmetry (Area)(%) | N/A | N/A | N/A | N/A | N/A | N/A |

| | Flatness (%) | Symmetry (%) | Diameter (mm) |
|---|---|---|---|
| X | N/A | N/A | 9.21 |
| Y | N/A | N/A | 9.23 |
| Positive Diagonal | N/A | N/A | 9.41 |
| Negative Diagonal | N/A | N/A | 9.51 |

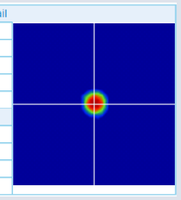

**Figure 6.** QA Analysis for 10 mm collimator size in Iris

## CONCLUSIONS

SRS MapCHECK system was successfully commissioned for CyberKnife MLC patient-specific QA. All verification plans were able to pass the QA tests using stringent gamma criteria. The system has demonstrated reliable performance across multiple treatment sites, supporting its clinical use for high-precision CyberKnife treatments.

## REFERENCES

1. Miften, M., Olch, A., Mihailidis, D., Moran, J., Pawlicki, T., Molineu, A., ... & Low, D. A. (2018). Tolerance limits and methodologies for IMRT measurement-based verification QA: recommendations of AAPM Task Group No. 218. *Medical physics*, *45*(4), e53-e83.

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