Non-Uniform Degradation of the aSi-1200 Electronic Portal Imaging Detector Due to Portal Dosimetry Quality Assurance of SRS/SBRT Plans

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ABSTRACT

Purpose:
Increased use of portal imaging for quality assurance of SRS/SBRT plans results in a higher workload for the center detector elements compared to the peripheral elements. This study aims to evaluate the long-term stability of the EPID under frequent SRS/SBRT QA use and to assess any spatially dependent degradation of detector performance.

Methods:
All measurements were conducted with a Varian Truebeam Edge and aSi-1200 EPID. Daily 6 MV beam uniformity was measured with MPC over a 1-year period. A 6 MV 10x10 cm^2 open field image was delivered daily. Five regions of interest were defined, one in the center and the remaining 4 cm away from the center in each cardinal direction. Image intensity values were recorded over a 10-week period in which MPC uniformity exhibited an upward trend between baselines. These were compared using a two-way repeated-measures ANOVA. Correlation was calculated between pixel value change and uniformity change. Portal dosimetry for a single-met SRS plan was measured bi-weekly to observe changes in resulting gamma values. Results will continually be recorded over a 6-month period.

Results:
Over a one-year period, uniformity values were observed to increase following baseline establishment and increased at an accelerated rate as the year progressed. Visual changes in flood-field images were observed over time, with the central region showing greater deviation relative to the baseline image. Statistically significant differences in pixel values were found between central and peripheral d etector regions over the 10-week period. No correlation was found between pixel value change and uniformity. Additionally, no significant changes were observed in gamma values from five preliminary SRS-QA measurements.

Conclusion:
Some evidence of non-uniform panel degradation has been observed based on flood-field images and increased uniformity deviation from baseline over time. However, these changes have yet to show any clinically significant impacts.

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INTRODUCTION

SRS and SBRT deliver high doses of radiation to small target volumes in one or a few treatment fractions. As these technologies have become more accessible, their clinical use has increased, with SRS utilization rising from 8% to 54% between 2004 and 2020. Because these treatments involve high doses and steep dose gradients, patient-specific quality assurance (PSQA) is essential to verify accurate and deliverable treatment plans.

PSQA can be performed using phantom-based measurements or portal dosimetry. Phantom-based PSQA methods are time-consuming, whereas portal dosimetry is more efficient. The use of the electronic portal imaging device (EPID) for PSQA of SRS/SBRT plans has been shown to provide accurate dose distribution measurements. Repeated measurements of high-dose treatment plans may result in nonuniform EPID degradation, with the central detector elements receiving greater radiation-induced damage than peripheral elements.

Our clinic supports a high-volume SRS and SBRT program, delivering an average of 175 treatments per month. This work evaluates the effects of EPID-based SRS/SBRT PSQA on EPID performance and investigates the potential impact of detector degradation on clinical QA measurements.

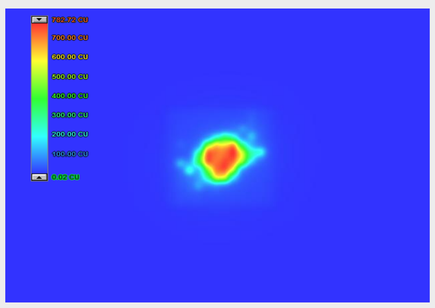

Fig 1. SRS PSQA 2D dose measured using the EPID.

METHODS AND MATERIALS

- Daily 6 MV beam uniformity was recorded with machine performance check (MPC).
- Flood-field and dark-field images were collected monthly over a 6-month period to visualize signal change.
- Portal dosimetry for a single-met SRS plan was measured weekly to observe changes in resulting gamma values. Measurements were taken weekly 5 weeks before panel replacement and 5 weeks after.
- Mutli-met Winston-Lutz results were recorded weekly for 11 weeks prior to panel replacement and 8 weeks after. Repeated measurements were taken same-day in the case of failure.

RESULTS

Evidence of panel degradation was apparent in flood-field/dark-field images, drift images, multi-met Winston-Lutz offset values, and image uniformity values.

Flood-field images over time (2025)

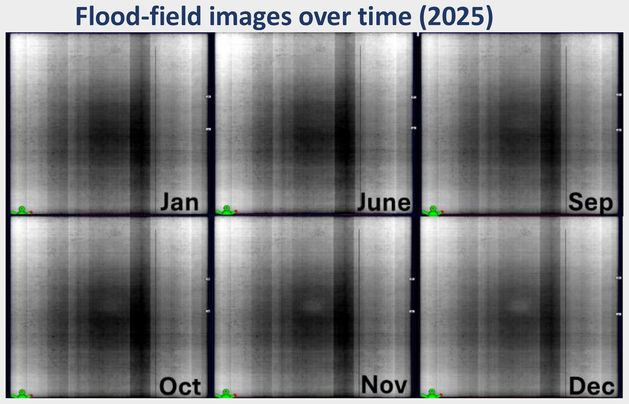

Fig 2. Uncorrected flood-field images from daily 6 MV MPC in 2025 with a field size of 18 x 18 cm^2. A notable change in intensity was observed, more prominent for later months, for the central region with approximately a 2 cm diameter.

Drift and dark-field images prior and post panel replacement

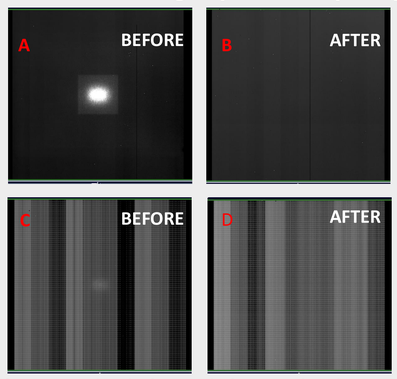

Fig 3. A & B) Drift images taken before and after panel replacement. The central detector element burnout is visible in A with the smaller circular degradation and larger square likely caused by daily irradiation of a 10x10 cm^2 for QA. **C & D)** Dark-field images taken before and after panel replacement.

Uniformity change

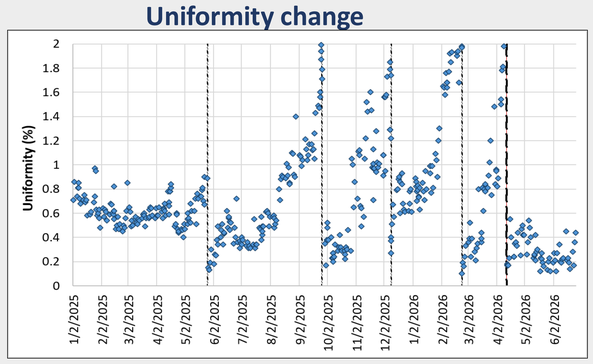

Fig 4. Uniformity changes over time for a 6 MV beam calculated from the daily MPC test. Panel calibrations occurred at the dotted vertical lines with dates May 26th , Sept 26th, Dec 9th, 2025, and Feb 23rd, April 12th 2026. Panel replacement occurred on April 12th, 2026, shown with the bold dotted line.

Multi-met Winston-Lutz offsets

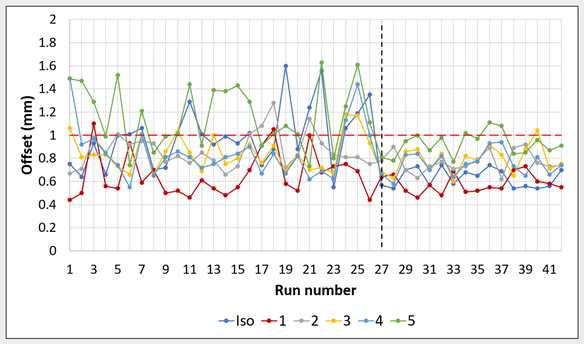

Fig 5. Multi-met Winston-Lutz results for the isocenter and 5 targets from Jan 26th, 2026, to June 8th, 2026, with the red horizontal line representing failure. The vertical axis presents maximum offset from iso or intended position for each target for all couch, gantry and collimator combinations. Panel replacement is represented by the dotted vertical line.

DISCUSSION

- Evidence of panel degradation was shown through flood-field/ dark-field and ratio images taken daily with MPC. The burnout size was approximately 2 cm in diameter and inferred to be a result of continuous PSQA of high dose SRS/SBRT plans.
- Visible changes in the images taken with MPC, coupled with an increase in uniformity values, led to a panel replacement.
- Uniformity values were analyzed from Jan 1st, 2025, to June 25th, 2026, with the panel replacement occurring on April 12th, 2026. Uniformity was observed to have an upwards trend following baseline of the panel. This upwards trend post baseline was not observed following panel replacement.
- The multi-met Winston-Lutz data showed multiple failed runs, including iso failure, prior to panel replacement. Decreased offset values and failing results were observed following the panel replacement.
- No clinically significant changes were observed in the measured gamma value of the single met plan before and after panel replacement. This is likely because the panel burnout was approximately uniform over the dose distribution given this was an SRS plan.

CONCLUSIONS

- Decreases in panel uniformity change, along with decreased multi-met Winston–Lutz offsets and failure rates following panel replacement, indicate that nonuniform EPID degradation had clinically significant impacts on quality assurance.
- The convenience of using portal dosimetry for PSQA may come at the cost of non-uniform panel degradation, the need for more frequent baselining, and ultimately more frequent panel replacement.
- Our clinic has implemented increasing the distance of the imager from 100 cm to 120 cm SID for SRS/SBRT PSQA to mitigate the risk of damage from increased exposure to middle elements.
- Further research could include lifetime comparisons of panels used for SRS/SBRT PSQA to those used for standard fractionated plans.

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