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Initial Experience of a High Resolution Solid-State Detector Array for Lattice Radiotherapy Treatments in Guatemala

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ABSTRACT

This study evaluates the accuracy of dose delivery in Lattice Radiotherapy (LRT) for large tumors using a high-resolution solid-state detector (myQA SRS, 0.4 mm resolution). Patient-specific QA (PSQA) was performed for 7 patients, comparing the performance of AAA and Acuros XB (AXB) algorithms. Gamma Index passing rates (GPR) were analyzed using 5%/1 mm global, 3%/1 mm global, and 3%/1 mm local criteria. AXB demonstrated superior agreement in high-gradient regions, with local 3%/1 mm GPR increasing from 77.0% (AAA) to 83.2% (AXB). The high-resolution detector proved to be an excellent tool for LRT verification, meeting clinical requirements.

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INTRODUCTION

Lattice Radiotherapy (LRT) delivers non-uniform, high-dose islands within large tumor volumes while sparing intervening tissues. This creates extreme dose gradients (peaks and valleys) that challenge both:

- **TPS Calculation Algorithms:** Discrepancies between Analytical Anisotropic Algorithm (AAA) and Acuros XB (AXB) in tissue-heterogeneity and high-gradient modeling.
- **Dosimetric Verification:** Traditional detector arrays lack the spatial resolution to accurately sample these sharp dose transitions.

Objective: To evaluate the clinical feasibility of a novel high-resolution solid-state detector array for LRT PSQA and compare AAA vs. AXB performance in Guatemala's initial clinical experience.

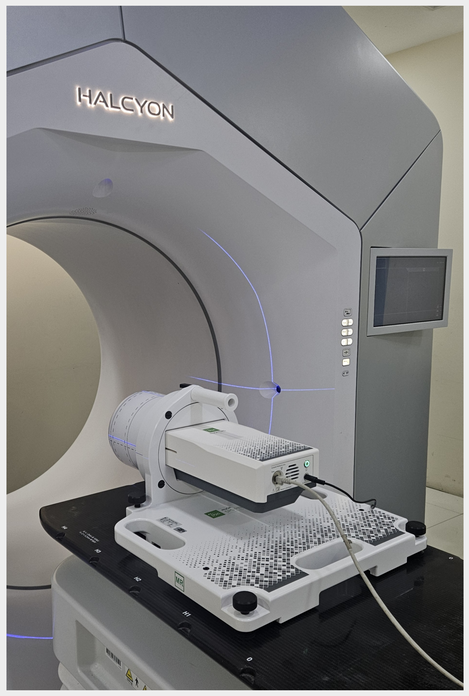

Figure 1. The detector was positioned according to the manufacturer's specifications. Measurements were performed on a Halcyon 6MV FFF to obtain the delivered dose distributions.

METHODS AND MATERIALS

MATERIALS

All treatment plans were optimized with the Eclipse v18 planning system and all dose deliveries were performed on a Halcyon 6MV FFF LINAC. For the dosimetric verification, myQA-SRS-2 was utilized, this detector has a resolution of 0.4mm and 105,000 pixels with an active area of 12x14 cm2.

METHODS

For the seven patients selected with large tumors treated with Lattice, following the recommendations from Washington University protocol, a PSQA was performed using the high resolution solid-state detector. For each patient, a measurement was simulated by placing the detector correctly. The measured planes were compared against a selected plane from the TPS calculated with AAA and AXB. Gamma Index passing rate was analyzed using global 5%/1mm, global 3%/1mm, and local 3%/1mm criteria, all with a 10% threshold.

RESULTS

Plans characterized by extreme dose peaks and valleys showed better agreement when calculated with XB. For 6 patients, the median for plans calculated with AAA were 95.2%±1.9% (global 5/1), 91.7%±3.6% (global 3/1) and 77.0%±4.5% (local 3/1). For AXB, the results were 96.2%±3.5% (global 5/1), 95.5%±4.6% (global 3/1) and 83.2%±6.6% (local 3/1). One additional patient was removed from the dataset because of low GPR due to extreme plan modulation.

Table 1. Individual GPR for AAA18 and XB18. The patient marked with * was removed from the posterior analysis.

Patient	AAA18			XB18		
	Global 5/1	Global 3/1	Local 3/1	Global 5/1	Global 3/1	Local 3/1
331796	96.30%	93.70%	79.00%	95.80%	95.40%	90.20%
334909	96.00%	91.30%	75.00%	96.50%	95.50%	88.00%
329944	97.20%	96.90%	84.10%	97.30%	96.70%	81.20%
333920	92.20%	92.10%	81.80%	90.70%	89.20%	71.50%
324548	93.30%	86.40%	72.50%	89.40%	85.70%	81.20%
332601	94.40%	89.60%	74.60%	97.10%	96.50%	85.20%
333035*	85.00%	63.70%	49.60%	92.20%	83.90%	72.40%
Mean (N=6)	**95.20%**	**91.70%**	**77.00%**	**96.15%**	**95.45%**	**83.20%**

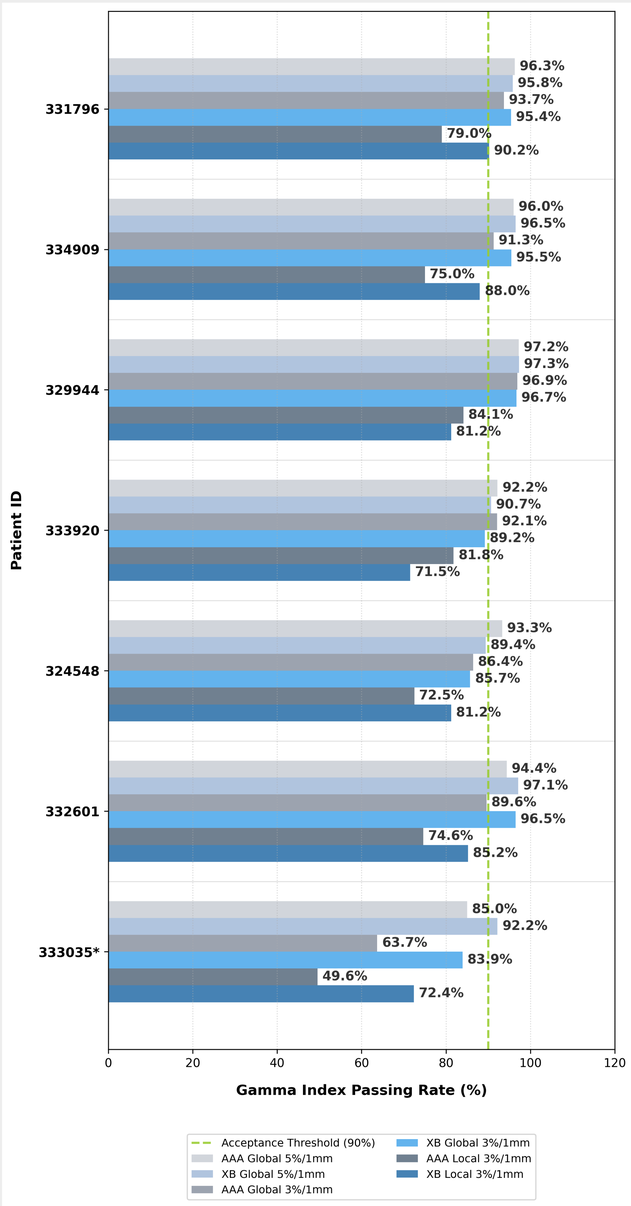

Figure 2. Comparison of Patient-Specific GPR.

DISCUSSION

- **Detector Performance:** The 0.4 mm resolution of the myQA-SRS-2 successfully resolved the rapid dose fall-offs characteristic of LRT, which conventional diode or ion chamber arrays (>2 mm pitch) often blur out due to volume averaging.
- **Algorithm Discrepancies:** While global gamma criteria (5%/1 mm) show acceptable results for both algorithms, the **local 3%/1 mm criteria uncovers a 6.2% drop in AAA accuracy**.
- This highlights AAA's limitations in modeling secondary electron transport in highly modulated, small FFF fields, whereas AXB's direct transport equation solver tracks these gradients more reliably.
- Extreme modulation can still challenge standard PSQA thresholds (as seen in the excluded patient), suggesting a need for custom protocol limits in hyper-fractionated LRT.

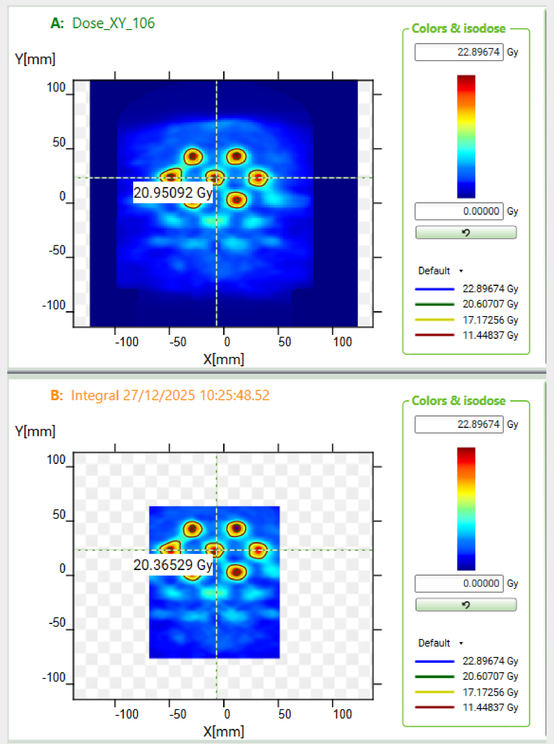

Figure 3. TPS dose maps were imported into the analysis software and was manually aligned to match the measured distribution in the analysis software.

CONCLUSIONS

Our results indicate that the high-resolution detector is an excellent option for PSQA of complex Lattice plans, giving results consistent with all the clinical requirements. The AXB showed higher agreement in high dose gradient regions compared with AAA.

REFERENCES

1. IBA Dosimetry GmbH (2023), myQA Machines Instructions for Use.
2. IBA Dosimetry GmbH (2024), myQA SRS Instructions for Use.
3. IBA Dosimetry GmbH (2024), myQA Patients Reference Guide.