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Fast pre-insertion dosimetry and source validation for Ru-106/I-125 ophthalmic plaque brachytherapy with 2D pixelated semiconductor detectors

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Introduction
Accurate dosimetry in ophthalmic plaque brachytherapy is essential due to steep dose gradients and the proximity of critical ocular structures. Current clinical practice relies on manufacturer-certified data with limited independent verification. This study reports on the development of a novel system for rapid pre-insertion validation of Ru-106 and I-125 plaques using high-resolution pixelated semiconductor detectors.
Methods
Two systems were developed based on a radiation sensor with a pixel size of 55 μm and a sensitive layer of 14 × 14 × 0.3 mm^3. The first uses a pinhole camera in air to image the activity distribution on the concave surface of a plaque. Pinhole geometry was optimized analytically and refined using Geant4 Monte Carlo simulations. The second system measures 2D depth–dose distributions in water by positioning the detector beneath a custom-designed phantom, with the plaque mounted on a movable stage to allow dose measurements at varying depths. Geant4 Monte Carlo simulations were performed to assess the feasibility of the dosimetry system.
Results
The activity-measurement system was manufactured and tested, demonstrating the the capability to rapidly map activity distributions in both I-125 and Ru-106 plaques. Monte Carlo simulations confirmed the feasibility of Ru-106 electron field dosimetry using the 0.3 mm-thick silicon layer of the detector. A prototype dosimetry system was designed and manufactured, with validation measurements scheduled for the third quarter of 2025; results will be presented at the AIP Summer Meeting.
Conclusion
These developments demonstrate the feasibility of fast, independent verification of Ru-106 and I-125 plaques. The developed systems have the potential to improve clinical safety and confidence in ophthalmic brachytherapy without compromising current clinical workflows with time-consuming measurements.

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