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Filmless MLC Quality Assurance in Robotic Radiosurgery

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Objectives: After clinical implementation of an MLC system for the CyberKnife (Accuray Inc., Sunnyvale, CA), a clinic is faced with an increased amount of QA that should be performed. Though the vendor provides the means (hardware and software) for this QA, these tests are inherently inefficient due to their reliance on film. The QAStereoChecker (Standard Imaging Inc., Middleton, WI) was designed specifically to efficiently analyze high-intensity stereotactic beams using a high-resolution flat-panel imager. The QASC performs filmless analysis of the CK's treatment localization and delivery systems, the variable-aperture collimator (Iris), as well as the MLC system. This study explores the capability of this device to detect out-of-tolerance events in the MLC system, while evaluating the efficiency of QA performed using the QASC as compared to film-based methods.

Methods: Accuray recommends a daily picket fence (PF) test. This non-quantitative test of leaf position accuracy is performed by irradiating film with a field consisting of contiguous segments of constant width and constant separation along the path of leaf travel. This procedure requires a film jig attached to the MLC housing. The user visually evaluates the film by ensuring that no leaf junctions are lighter or darker than other leaf junctions. Also recommended is a monthly garden fence (GF) test. This test allows for a quantitative analysis following a similar setup and scan as the PF test. While similar to the PF test, the GF test differs in that the MLC field width is not equal to the segment distance along the direction of MLC travel. This creates darkened gaps of constant width which allow individual analysis of each bank and their individual leaves. Accuray recommends that no single leaf position should vary by more than 0.5 mm from the intended leaf position, and that the average single leaf error for a leaf bank not exceed 0.2mm. The QASC is aligned automatically using the CK's fiducial tracking system. The GF pattern is delivered via a plan designed in the CK's treatment planning system (TPS). This allows the QA plan to be setup quickly, consistently, and delivered in an actual treatment delivery mode. Eleven GF plans were generated in the TPS. Each pattern set includes a plan with no leaf over-travel, as well as 10 plans where a leaf is intentionally over-traveled in increments of 0.1mm (from 0.1mm to 1.0mm).

Result: The QASC used baseline-compared difference image peak analysis, which allowed detection of individual leaf position deviations as low as 0.2mm (vendor tolerance being 0.5mm). For film-based QA, a well-trained CK user required 15 minutes for setup (and break-down), delivery, scanning, and visual analysis of a daily PF test. An additional 7 minutes was required to replace the visual analysis with that of a software-based analysis of a film irradiated using a GF pattern. Using the QASC, a PF was acquired in 5 minutes, with an additional 1 minute for the quantitative analysis associated with the GF test.

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Conclusions: Since the QASC performs quantitative GF tests quickly, the CK user can perform quantitative QA on their MLC system daily (as compared with monthly) and in 5 minutes (as compared with 22 minutes).