Clinical Significance Of Leaf Modifications And Their Detectability With Two Quality Assurance Devices For Rapidarc Plans

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Purpose/Objective(s): For this study DICOM files of clinical Rapidarc plans were modified with in-house developed software to mimic leaf alignment errors and gravitation shifts. The effects of these simulated errors are investigated with respect to changes in the patient’s dose distribution as well as in quality assurance measurements with the Octavius 2D-ARRAY (PTW-Freiburg) in sagittal and coronal orientation and the Delta4 device (Scandidos). In our study we try to establish a connection between the passing rate of QA measurements with both devices for small leaf alignment errors and their clinical significance by recalculating the manipulated plans in Eclipse.

Materials/Methods: Different errors were simulated and applied to five prostate (two arcs), three 2-arc head&neck and three 3-arc head&neck cases: (1) both MLC banks are opened by 0.25mm, 0.50mm and 1.00mm in opposing directions resulting in larger fields, (2) both MLC banks are closed by 0.10mm, 0.25mm and 0.50mm, (3) both MLC banks are shifted in the same direction for lateral gantry angles to simulate effects of gravitation forces onto the leaves by 1mm, 2mm and 3mm. In order to detect the modifications the QA measurements were evaluated according to a gamma-index criterion of 2mm/2% and a passing rate of 90%. All modified plans are recalculated in Eclipse and the dose volume histograms are analyzed with respect to the minimum, maximum and mean dose to the PTV.

Results: The opening of both MLC banks has a direct effect on the mean dose, increasing it by 3%-6% for the largest modification of 1mm. These plans fail the passing rate for both devices. Closing the leaves has a similar effect, decreasing the mean dose by >3% for prostate cases and >1% for head&neck cases. Simulated gravitation shifts drastically change the minimum and maximum dose of the PTV while the mean dose stays within ±2% for a 3mm shift. Although even a 2mm shift shows a >8% decreased minimum and >3% increased maximum dose to the PTV the QA measurements fail a >90% passing rate only in half of the cases. With the standard criteria (3mm, 3%) even the largest modifications would satisfy a >90% passing rate. This indicates that a global criterion for the passing rate may not be sufficient in all cases. All unmodified plans and the majority of the plans with the smallest modification pass the $\gamma$-index criterion of 2%/2mm with >90%.

Conclusions: Both devices are able to detect MLC positional errors of the investigated magnitude. A stricter $\gamma$-index (2mm, 2%) is necessary in order to detect MLC positional errors and a passing rate of >90% should be expected. This still does not always guarantee that positional errors with clinical significance are detected. A closer look as to where discrepancies occur and professional judgment is needed when interpreting the $\gamma$-index analysis.