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Abstract
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Plan Robust Comparison between DCA and VMAT for Single-Isocenter Multi-Lesion Stereotactic Radiosurgery (SRS) Treatments

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Abstract

Objectives:

Dynamic conformal arc (DCA) and Volumetric Modulated Arc Therapy (VMAT) are common treatment options for Linac-based single-isocenter multi-lesion stereotactic radiosurgery (SRS). In prior plan comparison studies, it was observed that VMAT exhibited superior conformal dose distribution to the targets compared to DCA. Several studies have shown that dose coverage of off-axis targets is sensitive to setup uncertainties. However, studies have yet to evaluate whether VMAT or DCA plans are more robust in the presence of setup uncertainties. Thus, this work aims to compare the robustness of DCA and VMAT plans to translational or rotational setup uncertainties with respect to changes in target-dose coverage.

Methods:

15 patients (105 metastases, 4-10 metastases per patient) were included in this study. Two plans (DCA and VMAT) were generated for each patient using the same isocenter and the same PTV coverage goal. The dose distribution was virtually shifted/rotated around the isocenter and then used to re-calculate the dose-volume histogram (DVH) for each PTV. Translations in three directions and rotations around three axes (total 12 scenarios including 6 shifts and 6 rotations) were simulated separately to evaluate the dosimetric impact. In this study, translation/rotation of 1mm/1°, 2mm/2° and 3mm/3° were simulated. The dosimetric changes of the PTVs were evaluated using both V100 [%] (the relative volume covered by the prescribed dose) and D99 [%] (the relative minimum dose delivered to 99% of the PTV). For each PTV, the average value of V100 and D99 of the 12 scenarios were calculated to present the impact of the translations and rotations. Additionally, conformity index (CI) was reported for each DCA and VMAT plan. We tested for significant differences regarding V100 change, D99 change as well as CI between DCA and VMAT plans with paired Wilcoxon Signed Rank tests ($\alpha = 0.05$).

Results:

VMAT plans had more favorable conformity (median CI for DCA: 1.27; median CI for VMAT: 1.18; $p< 0.01$). As seen in the 1mm/1° simulation, the median values of V100 and D99 decreased by 6.1% and 9.3% in the DCA plans, respectively; while the median values of V100 and D99 dropped by 5.6% and 8.7% in VMAT plans, respectively. For PTVs with volume ⩾0.5 cc, V100 was reduced by a median of 1.0%, 2.0%, and 2.7% more in VMAT plans than DCA plans for 1mm/1° ($p=0.016$), 2mm/2° ($p< 0.01$) and 3mm/3°($p< 0.01$) simulations, respectively. There was no significant difference in V100 changes from the nominal plan between DCA and VMAT for the smaller PTVs with volume < 0.5 cc. However, D99 reduced by a median of 0.60%, 1.49% and 2.08% more on DCA plans than VMAT plans, for 1mm/1° , 2mm/2° and 3mm/3° simulations, respectively. D99 was slightly more sensitive to the setup uncertainties for DCA plans than VMAT plans ($p< 0.01$).

Conclusion(s):

We compared the plan sensitivity between DCA and VMAT based on the dosimetric impact of translations or rotations for single-isocenter SRS treatments (4-10 metastases per treatment). Our data indicate that DCA plans were slightly more robust regarding V100 for PTVs with volume ⩾0.5 cc while VMAT plans were more robust regarding D99. Overall, DCA and VMAT plans have similar robustness against setup uncertainty. To ensure target coverage and prevent the under-dosing of targets, it is essential to employ advanced image

guidance, rigorous setup procedures with tight tolerances, and active monitoring of intra-fraction motion regardless of the treatment option employed.