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Evaluation of Brainlab Elements SIMT SRS Plan Robustness to Geometrical Uncertainties with PTV Margins

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Purpose

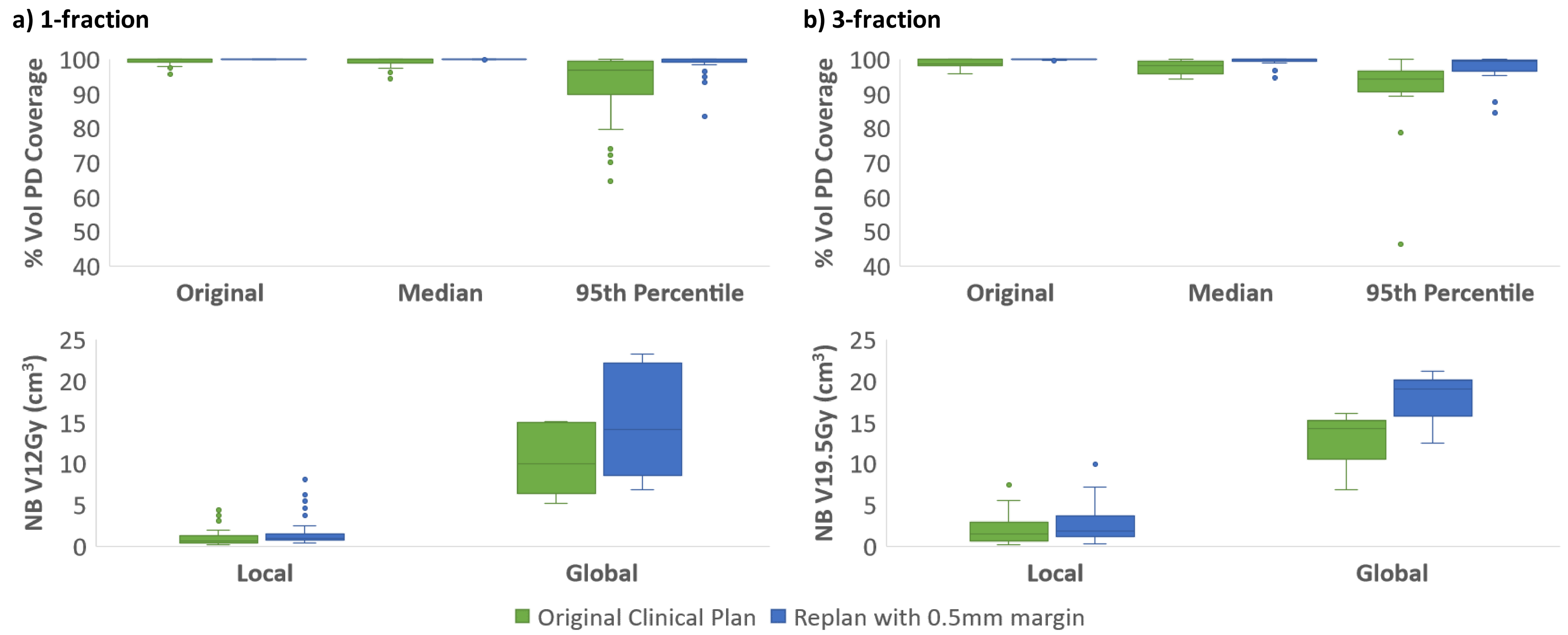
At the Royal Marsden Hospital, Brainlab Elements treatment planning system is employed to treat multiple brain metastases using the single isocentre for multiple target stereotactic radiosurgery (SIMT SRS) technique. A zero GTV-PTV margin approach is adopted except for metastases smaller than 0.02cc. While using no margin may reduce the risk of brain necrosis [1], several papers have recommended adding a margin for SIMT treatments to ensure adequate dose coverage to metastases [2, 3]. The aims of this study was, therefore, to derive an optimal margin for SIMT SRS at our centre and to evaluate plan robustness to residual setup errors and linac delivery error with and without this optimal margin.

Materials and Methods

The plan robustness to both residual setup error and linac delivery error was evaluated. Residual setup errors of 13 patients (8 1-fraction patients with a total of 78 metastases and 5 3-fraction patients with a total of 32 metastases) were first quantified. Linac delivery error was measured through multi-metastases-Winston-Lutz measurements. PTV margins were then calculated using van Herk margin recipe [4]. Patient scans were translated and rotated by the median of the combined uncertainties to mimic a nominal situation and also by the 95th percentile error for a near worst case scenario, using the software 3D Slicer. The plans were subsequently recalculated. Previous patients' plans were replanned as well with the derived margins. Effects on GTV coverage with the prescription isodose and normal brain doses were assessed.

Results

Mean (±stdev) coverage of all targets in the original plans were 99.4% (±0.9%) and 98.9% (±1.0%) for 1 and 3-fraction patients respectively. Median geometrical errors did not result in significant differences. A statistically significant reduction in coverage to 91.4% (±10.4%) and 93.0% (±9.6%) was seen under 95th percentile errors. Applying the derived optimal margin of 0.5mm resulted in 78% of the GTVs retaining coverage of 98% or above even in the presence of 95th percentile errors, compared to only 30% if no margins were applied. Replanning with margins also caused no significant increase to local normal brain doses, however global dose increases varied according to the number of metastases.



Boxplots showing the % volume of GTV covered by the prescription dose (PD) under different degree of geometrical uncertainties, and the volume of local and global normal brain (NB) receiving the local dose constraints of V12Gy (for 1-fraction) and V19.5Gy (for 3-fraction), with and without margins

Conclusion

Plans were shown to be robust to average geometrical uncertainties despite targets having no margins, however occurrence of GTV under-coverage increased under near worst case 95th percentile scenarios. The margin was proven to substantially improve the target dose coverage with limited change to local normal brain doses, although not all sources of geometrical uncertainty were considered.

References

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