

Optimisation strategy and conformity guidance for mono-isocentre SRS VMAT of targets <0.5cm diameter

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INTRODUCTION

Stereotactic Radiosurgery (SRS) is delivered successfully to a wide range of target sizes using a well-established mono-isocentric non-coplanar VMAT technique utilising High Definition MLC's². A 1mm margin is routinely added to all GTV's to create the PTV.

The challenges of treating targets of GTV <0.5cm diameter are mitigated by introducing a novel planning technique. An additional planning margin is added the PTV to ensure the volume for the plan optimisation is not <0.8cm diameter. This new structure, called PTVedit, is used in the optimiser only.

Consequently the planning indices used to determine an acceptable plan do not fall into line with targets which do not require this larger planning volume.

AIM

The actual PTV (GTV +1mm margin) is used to determine plan assessment metrics including conformity, selectivity, paddick and gradient indices³. This work reports the achieved planning metrics using this novel planning strategy and presents a new set of planning guidelines for the Conformity Index (CI = Body V100%/PTV V100%) to reflect the expected results of this practice.

METHOD

For 109 individual targets of <0.1cc, all in multiple metastatic treatments, if a GTV had a diameter of ≤0.5cm (generally equating to <0.1cc) an optimisation PTV was created with a diameter of 0.7-0.8cm. This limit was chosen to prevent the HDMLC's attempting to create apertures smaller than techniques such as Gamma Knife (0.4cm) and Cyberknife (0.5cm).

Treatment was planned and optimised to this larger optimising PTV, but the plan normalised to the actual PTV (GTV+1mm). For this reason, conformality and selectivity are compromised and this has been accepted by the clinicians as a limitation of treating very small targets using VMAT SRS.

RESULTS

Figure 1 shows CI results for 109 patients with GTV target volumes of <0.1cc (generally equating to a diameter of <0.5cm)

As expected, for targets ≥0.5cm diameter (≥0.06cc) CI remains close to 1, as there has been no additional planning margin added in these cases.

When the GTV diameter is <0.5cm and PTVedit is used in the optimiser the conformity to the actual PTV worsens, as expected due to the system optimising to a larger target and being pushed to use a larger aperture.

The median CI reduces as the GTV size increases, because the optimising PTVedit and actual PTV become closer in size as the GTV volume increases and the conformity improves.

The statistical results are presented in Table 1. There were outliers in cases of high CI in plans result from the earliest days of using this planning technique with least experience and do not represent the median results.

This planning guidance therefore recommends that as GTV volume increases from 0.01cc, the maximum recommended CI will decrease by 0.5 for each 0.01cc of GTV volume. This means that planners will be aware that although conformity is expected to decrease, there is an acceptable limit even for small targets. This should eliminate the outliers seen the range of results going forward.

This guidance has been implemented and CI maximum thresholds have now been set based on this data.

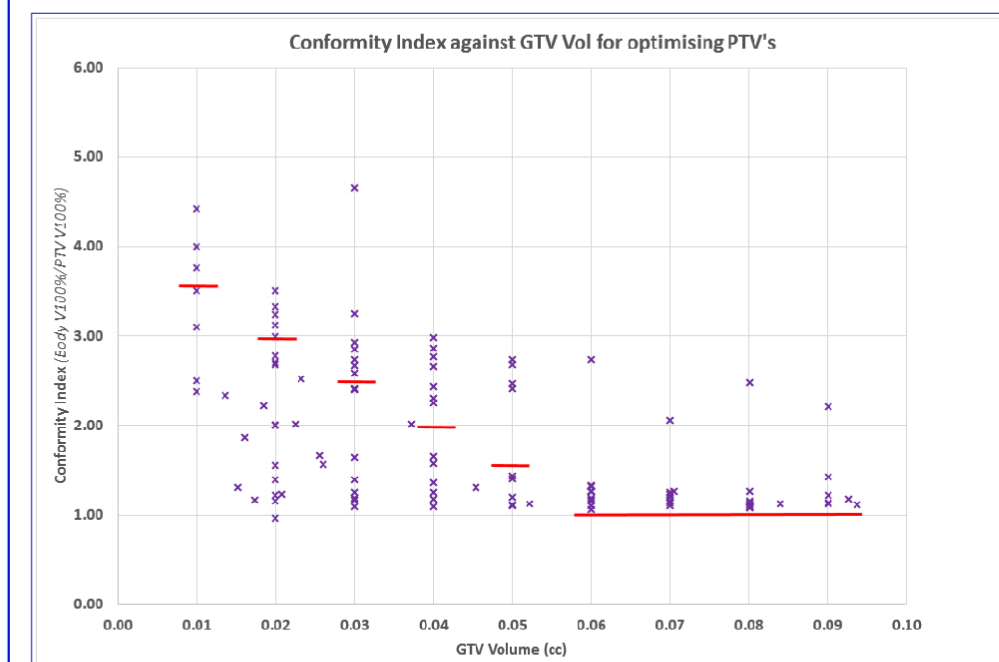


Figure 1 – GTV volume (cc) vs rs conformity index (CI) for 109 patients with GTV <0.1cc

GTV Vol (cc)	Number Targets	Median	Range	Standard Deviation	Planning Guidance CI Max
0.01	9	3.5	2.34-10.4	2.5	3.5
0.02	24	2.01	0.97-6.54	1.19	3
0.03	17	2.4	1.09-4.66	0.96	2.5
0.04	14	2.14	1.09-2.96	0.67	2
0.05	11	1.41	1.11-2.74	0.69	1.5
0.06	11	1.26	1.06-2.74	0.47	1
0.07	8	1.22	1.1-2.05	0.31	1
0.08	9	1.12	1.08-2.48	0.45	1
0.09	7	1.17	1.11-2.2	0.39	1

Table 1

Table 1 - Statistical breakdown of GTV's <0.1cc and proposed planning guidance for CI max

CONCLUSIONS

A novel strategy has been presented to allow treatment of targets ≤0.5cm diameter, along with guidance for limits of CI for a range of target sizes.

The plans for these cases are still highly conformal and clinically acceptable, but represent a more realistically achievable treatment delivery than if they had been fully optimized to the actual PTV.

This guidance will allow meaning to be attributed to currently un-utilised (in small GTV cases) plan assessment metrics and produce more consistent and conformal plans. These guidelines will be reviewed and limits potentially reduced further in due course.

ACKNOWLEDGEMENTS

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REFERENCES

² Clark, G.M. et al. (2012). Plan quality and treatment planning technique for single isocenter cranial radiosurgery with volumetric modulated arc therapy. Practical Radiation Oncology, 2(4), pp.306–313. [online]. Available from: <http://www.sciencedirect.com/science/article/pii/S1879850011003791>.

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