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Evaluation of Plan Quality and Delivery Time in SRS for Multiple Brain Metastases: A Comparative Study

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Background

Stereotactic Radiosurgery (SRS) is the preferred treatment for limited multiple brain metastases (MBM). Gamma Knife (GK) SRS is a dedicated platform that achieves high accuracy and conformity with a fast fall-off, at the expense of significant treatment time when there are multiple lesions. LINAC-based SRS utilises either a multiple isocentre technique (MIT) or a single isocentre technique (SIT). SIT has the advantage of a faster setup time at the expense of a compromised conformity and higher low-dose bath when compared to MIT and GK. The present study aims to compare GK, MIT and SIT in terms of plan quality indices, low-dose bath to the brain and treatment efficiency.

Materials and Methods

This retrospective study included 8 patients with MBM (35 lesions in total). For each case, plans were generated using three different treatment planning systems (TPS): Leksell GammaPlan for GK, Brainlab Elements Cranial for MIT and Brainlab Elements MBM for SIT. No PTV margin was applied for GK and a 1mm PTV margin was applied for MIT and SIT plans. For MIT, spacially adjacent lesions were grouped into a single isocentre; lesions had a spatial separation of 7cm maximum. Treatment was delivered using a Varian Clinac iX linear accelerator using a frameless technique. Dose prescription ranged from 18-20Gy. For each lesion, we compared PTV coverage, inverse PCI, GI and lesion V12Gy achieved with different TPS. For each individual patient, we compared whole brain Dmean, V3Gy, V4Gy, and estimated overall treatment time (OTT) for each treatment plan (including setup and beam-on time).

Results

Treatment details are tabulated in Table 1. GTV volumes were generally small (median, 0.084cc). PTV coverage was high with all three TPS. iPCI was best with MIT, followed by SIT, followed by GK. Both performed significantly better than GK ($p<0.001$ in both cases). GK produced superior GI, lesion V12Gy, and whole brain Dmean/V3Gy/V4Gy. Median OTT was significantly shorter using MIT and even shorter using SIT.

Conclusions

SIT significantly reduced treatment time while maintaining plan quality. MIT has comparable iPCI to GK at the cost of larger treatment volume. It remains a cost effective, practical option, especially for cases where lesions are far apart and/or if different dose/fractionations are required. GK, if available, can minmise V12Gy and low-dose bath to the brain when required (for example in re-irradiation situations), at the cost of significantly longer treatment time.

	GK (Gamma Plan)	MIT (Brainlab Cranial)	SIT (Brainlab MBM)
Lesions treated, median (range)	3.5 (2-9)		
GTV volume (cc), median (IQR)	0.084 (0.037-0.253)		
PTV volume (cc), median (IQR)	N/A	0.251 (0.143-0.570)	
Coverage (%), median	99.0	99.5	99.2
iPCI, median	1.75	1.28	1.43
GI, median	3.46	3.96	4.18
Lesion V12Gy, median	0.53	0.82	1.00
Whole brain Dmean (Gy), median	0.55	1.22	1.46
Whole brain V3Gy (cc), median	25.0	79.0	90.0
Whole brain V4Gy (cc), median	15.5	41.5	46.5
OTT (minutes), median	60.0	46.5	21.5

Table 1 Treatment Information.

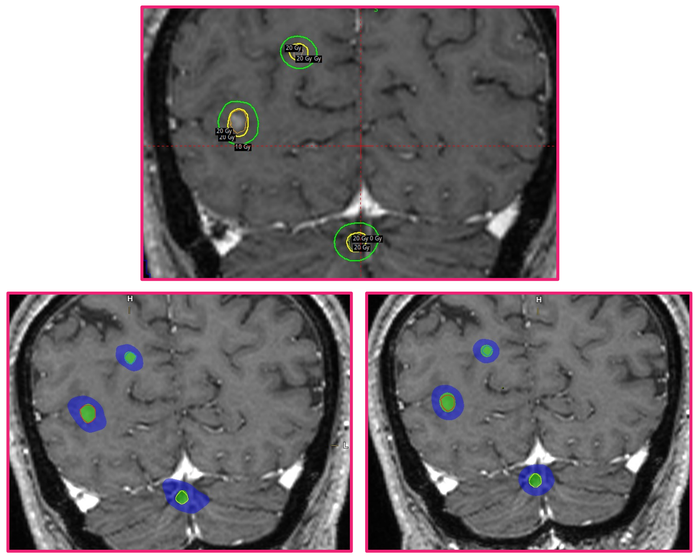


Figure 1 Isodose distributions on different TPS for a representative case (100% and 50% isodose). Clockwise from top: GK, SIT, MIT