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Comparison of Brain Dose Metrics Among Multiple Stereotactic Radiosurgery Delivery Platforms For Brain Metastases

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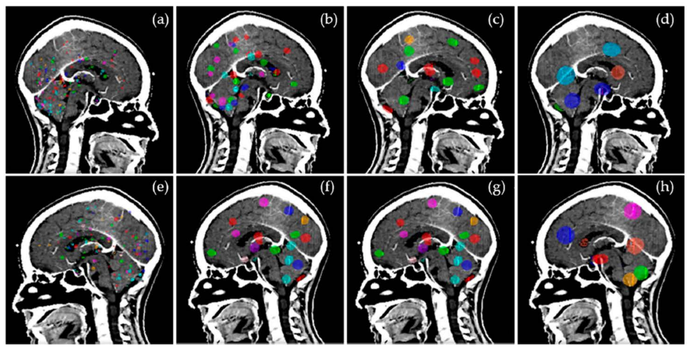
Purpose

This study compares brain dose metrics evaluated using multiple dedicated stereotactic radiosurgery (SRS) delivery platforms for the treatment of brain metastases.



Target distribution of brain mets for Groups 1-4 as viewed from left (a-d) and right (e-h).*

*La Rosa A, Wieczorek DJJ, Tolakanahalli R, Lee YC, Kutuk T, Tom MC, Hall MD, McDermott MW, Mehta MP, Gutierrez AN, Kotecha R. Dosimetric Impact of Lesion Number, Size, and Volume on Mean Brain Dose with Stereotactic Radiosurgery for Multiple Brain Metastases. Cancers (Basel). 2023 Jan 27;15(3):780. doi: 10.3390/cancers15030780. PMID: 36765738; PMCID: PMC9913147.

Methods & Materials

- Four sets of gross tumor volumes (GTVs), grouped by lesion size (Group1: ≤5mm, Group2: >5-10mm, Group3: >10-15mm, and Group4: >15mm), were contoured.
- SRS plans (20 Gy in 1 fraction) were generated using Gamma Knife (GK) Leksell GammaPlan Version v11.3.2, Cyberknife (CK) Precision Version v3.3.1.2, and ZAP-X vDB-1011.
- Plans for each group started with a nominal number of lesions which were progressively increased until the mean brain threshold dose of 8Gy was reached.
- The brain volume receiving 8, 10, and 12 Gy (V8Gy, V10Gy and V12Gy), mean brain dose, total GTV volume, and total number of lesions were compared.

	Group 1 (<5mm)			Group 2 (5-10mm)			Group 3 (>10-15mm)			Group 4 (> 15mm)		
	GK	ZAP-X	CK	GK	ZAP-X	CK	GK	ZAP-X	CK	GK	ZAP-X	CK
	177	120	135	57	41	35	29	22	18	10	9	8
Total GTV Volume (cc)	3.62	2.12	2.32	20.37	14.24	12.09	30.25	22.35	18.24	57.96	49.03	41.52
Mean GTV Vol (cc)	0.020 ± 0.017	0.018 ± 0.016	0.017 ± 0.016	0.357 ± 0.141	0.344 ± 0.15	0.352 ± 0.16	1.043 ± 0.259	1.016 ± 0.243	1.014 ± 0.261	5.794 ± 1.776	5.446 ± 1.508	5.188 ± 1.348
GTV Volume Range (cc)	[0.001, 0.081]	[0.001, 0.064]	[0.001, 0.064]	[0.116, 0.619]	[0.116, 0.619]	[0.116, 0.619]	[0.53, 1.567]	[0.53, 1.427]	[0.53, 1.427]	[3.535, 8.922]	[3.535, 7.509]	[3.535, 6.881]
Mean GTV Dimension (mm)	3.6 ± 1.0	3.4 ± 1	3.4 ± 1	9.0± 1.1	8.9 ± 1.3	8.9 ± 1.3	13.8 ± 1.1	13.8 ± 1.2	13.8 ± 1.2	23.4 ± 2.1	23.14 ± 2.08	23.0 ± 2.2
GTV Dimension Range (mm)	[1.8,5]	[1.8,5]	[1.8,5]	[6.1,9.9]	[6.1,9.9]	[6.1,9.9]	[10.8, 14.9]	[10.8, 14.9]	[10.8, 14.9]	[19.8, 26.1]	[19.8, 26.1]	[19.8, 26.1]
Median GTV Dimension (mm)	3.8	3.3	3.2	9.8	9.6	9.8	13.8	14.0	14.3	24.0	23.7	23.4

Table 1. Summary of lesion and corresponding volume grouped by size to reach a mean brain dose of 8 Gy.

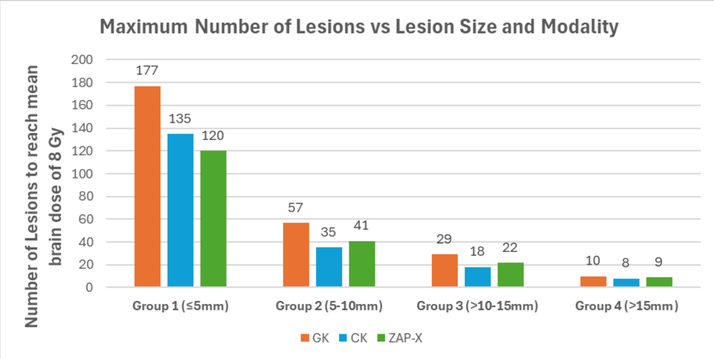


Figure 3: Variation of maximum number of targets among modalities decreases with increasing lesion size.

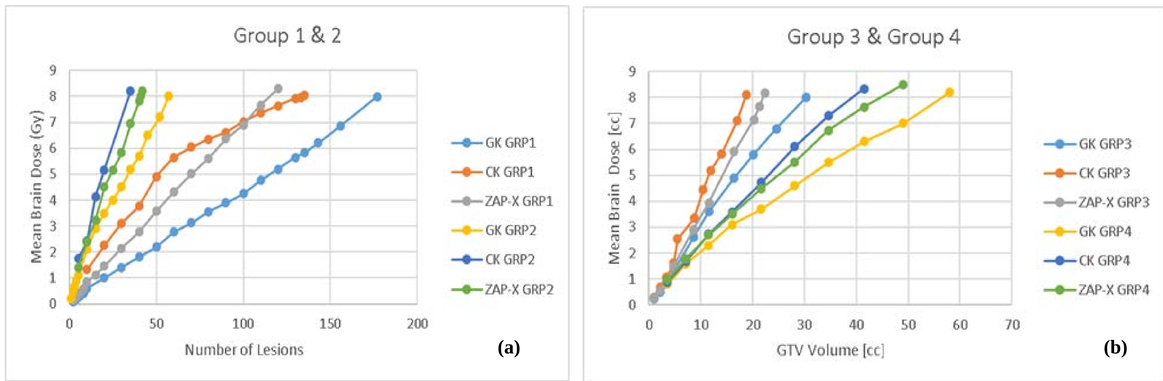


Figure 1a-b. Mean brain dose is linearly proportional [correlation coefficient of ≥ 0.97 (for CK Group1), 0.99 for the rest] to the number of lesions and to the total GTV volume.

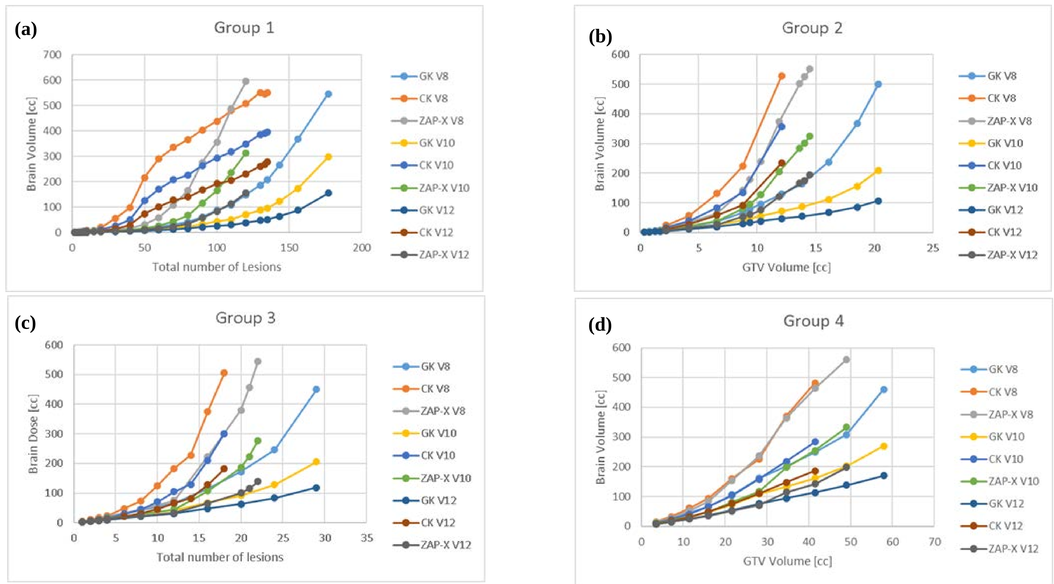


Figure 2a-d: V8Gy, V10Gy, and V12Gy shows a quadratic correlation to the number of lesions and the total GTV volume for Group1-4. GK shows the least dose contribution to the brain dose followed by Zap-X and then CK.

Results

- Across all simulated plans, the mean brain dose was linearly proportional (correlation coefficient: 0.99) to the number of lesions and total GTV volume.
- Maximum number of lesions and corresponding GTV volumes needed to reach the mean brain dose of 8 Gy were **177**[3.62cc], **57**[20.37cc], **29**[30.25cc], and **10**[57.96cc] for Groups 1-4 for **GK**, **135**[2.32cc], **35**[12.09cc], **18**[18.24cc], and **8**[41.52cc] for **CK**, and **120**[2.12cc], **41**[14.24cc], **22**[22.35cc], and **9**[49.03cc] for **Zap-X**.
- V8Gy, V10Gy, and V12Gy had a quadratic correlation to the number of lesions and the total GTV volume, with GK giving the least contribution to the normal brain, followed by Zap-X, and CK.

Conclusion

Mean brain dose was found to increase linearly with number of lesions and total GTV volume while select metrics such as V8Gy, V10Gy, and V12Gy showed a quadratic correlation to the number of lesions and the total GTV volume. GK was found to contribute the least to the integral brain dose, followed by Zap-X and then CK.