

Initial Evaluation of Krylov Optimizer for ZAP-X Stereotactic Radiosurgery

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Background & Objectives

- A new optimizer is planned for the ZAP-X stereotactic radiosurgery (SRS) treatment planning system (TPS) upgrade version 1012, utilizing a Krylov algorithm (1).
- In this study, ZAP-X TPS 1012 beta version is evaluated against the current TPS version 1011 along with Edge SRS on a single plan for dosimetric comparison.

Methods

- A single Brain Metastases plan was selected for this study, consisting of six targets.
- All plans were optimized under the same constraints to reach $\geq 99\%$ coverage on the target for 24 Gy in 3 fractions.
- The plans were compared with each other for gross target volume (GTV) coverage, conformity index (CI), and gradient index (GI), and for dose constraints on organs-at-risks (OARs) as recommended by Timmerman 2021 (2).

← Optimization									
	Type		Value	Weight	%	#	Solution		
1	PTV1-6	Boundary	$\geq$ 2400.0	100.0	100				
2	PTV1-6	Boundary	$\leq$ 2,400.0	100.0	100				
3	PTV1-6	Ext. (5 mm)	$\leq$ 0.0	99.0	100				
4	Beams		$\leq$ 200.0						
5	Eye_L	n Beams							
6	Eye_R	n Beams							
7	Oral_Cavity	n Beams							
8	Eye_L	Interior	$\leq$ 0.0	300.0	100				
9	Eye_R	Interior	$\leq$ 0.0	300.0	100				

Figure 1. Dose constraints used for optimization of ZAP-X TPS 1011 and 1012 plans.

Results

- The average GTV CI for 1012 was 1.22 ± 0.13 , for 1011 was 1.22 ± 0.12 , and for Edge was 1.25 ± 0.17 .
- The average GTV GI for 1012 was 3.3 ± 0.8 , for 1011 was 3.3 ± 0.7 , and for Edge was 4.5 ± 1.3 .
- The average OAR dose to 0.035 cm^3 volume for 1012 was $89 \pm 17 \text{ cm}^3$, for 1011 was $90 \pm 50 \text{ cm}^3$, and for Edge was $90 \pm 20 \text{ cm}^3$.
- The Brain volume (Brain - GTV) receiving 1200 cGy (V1200cGy) for 1012 was 10.07 cm^3 , for 1011 was 24.61 cm^3 , and for Edge was 19.18 cm^3 .
- The treatment time for 1012 was 60 minutes, for 1011 was 50 minutes, and for Edge was 30 minutes.

Table I. Dosimetric parameters for 1012, 1011, and Edge plans on a single Brain Metastases patients consisting of six targets.

Dosimetric Parameter	Metric	Constraint	1011	Edge	1012
GTV 1	V100 (%)	$\geq 95\%$	99.4%	99.4%	99.1%
	CI	$\leq 1.2 - 1.5$	1.22	1.44	1.42
	GI	$\leq 4.3 - 5$	2.01	2.91	3.91
GTV 2	V100 (%)	$\geq 95\%$	99.5%	99.2%	99.0%
	CI	$\leq 1.2 - 1.5$	1.16	1.12	1.21
	GI	$\leq 4.3 - 5$	3.63	6.42	2.94
GTV 3	V100 (%)	$\geq 95\%$	99.1%	99.9%	99.00%
	CI	$\leq 1.2 - 1.5$	1.19	1.175	1.26
	GI	$\leq 4.3 - 5$	3.82	5.77	2.84
GTV 4	V100 (%)	$\geq 95\%$	99.1%	99.9%	99.1%
	CI	$\leq 1.2 - 1.5$	1.371	1.502	1.25
	GI	$\leq 4.3 - 5$	3.567	4.24	4.51
GTV 5	V100 (%)	$\geq 95\%$	97.3%	99.9%	99.9%
	CI	$\leq 1.2 - 1.5$	1.07	1.121	1.09
	GI	$\leq 4.3 - 5$	3.567	4.242	2.62
GTV 6	V100 (%)	$\geq 95\%$	97.3%	100%	99.0%
	CI	$\leq 1.2 - 1.5$	1.079	1.131	1.07
	GI	$\leq 4.3 - 5$	3.056	3.587	2.7
Left Optic Nerve	D0.035cc (cGy)	$\leq 1740 \text{ cGy}$	146.8 cGy	86.7 cGy	97 cGy
	V1530cGy (cm ³)	$\leq 0.2 \text{ cm}^3$	0 cm ³	0 cm ³	0 cm ³
Right Optic Nerve	D0.035cc (cGy)	$\leq 1740 \text{ cGy}$	82.9 cGy	108.6 cGy	105 cGy
	V1530cGy (cm ³)	$\leq 0.2 \text{ cm}^3$	0 cm ³	0 cm ³	0 cm ³
Optic Chiasm	D0.035cc (cGy)	$\leq 1740 \text{ cGy}$	191.7 cGy	118.8 cGy	115 cGy
	V1530cGy (cm ³)	$\leq 0.2 \text{ cm}^3$	0 cm ³	0 cm ³	0 cm ³
Left Cochlea	D0.035cc (cGy)	$\leq 1440 \text{ cGy}$	113.2 cGy	113.2 cGy	96 cGy
Right Cochlea	D0.035cc (cGy)	$\leq 1440 \text{ cGy}$	79.9 cGy	108.6 cGy	95 cGy
Left Lens	D _{max} (cGy)	$\leq 100 - 200 \text{ cGy}$	52.2 cGy	50.8 cGy	65 cGy
Right Lens	D _{max} (cGy)	$\leq 100 - 200 \text{ cGy}$	54.6 cGy	54.0 cGy	64 cGy
Left Eye	D _{max} (cGy)	$\leq 100 - 200 \text{ cGy}$	64.9 cGy	85.3 cGy	82 cGy
Right Eye	D _{max} (cGy)	$\leq 100 - 200 \text{ cGy}$	64.9 cGy	90.8 cGy	81 cGy
Brain - GTV	V1200cGy (cm ³)	$\leq 10 \text{ cm}^3$	24.61 cm ³	19.18 cm ³	10.07 cm ³

Conclusion

- ZAP-X TPS version 1012 demonstrates an improvement in plan quality compared to 1011.
- Plans made by 1012 may reduce Brain V1200cGy significantly, with possible longer treatment time compared to 1011 and single isocenter Edge.

References

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