Initial Experience with Gyroscopic Stereotactic Radiosurgery for Spinal Tumors

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Objectives

- The ZAP-X is the newest cranial stereotactic radiosurgery (SRS) platform.
- There are no reports describing its use or outcomes for spinal tumors (STs).
- We report our initial experience using this system to treat STs at Jersey Shore University Medical Center with the intention to expand the existing base of literature on this novel therapy.
- In this case study, dosimetric parameters are analyzed for ZAP-X ST SRS along with initial clinical outcomes.

Methods

- Three patients were treated with ZAP-X ST SRS.
- Patient 1 was a 39-year-old female with a 3.00 cm^3 C2-C3 schwannoma treated with 3 fractions for 24 Gy to the 56% isodose line using 8 isocenters, 5, 7.5, 10 mm collimators, path 12 gantry movement, and 212 beams.
- Patient 2 was an 83-year-old female with a 0.61 cm^3 C1 meningioma treated with 5 fractions for 30 Gy to the 66% isodose line using 16 isocenters, 4, 5, 7.5 mm collimators, and path 6 gantry movement, and 280 beams.
- Patient 3 was a 59-year-old male with a 6.29 cm^3 C1-C2 prostate cancer metastasis treated with 5 fractions for 30 Gy to the 63% isodose line using 13 isocenters, 5, 7.5, 10, 12.5 mm collimators, path 10 gantry movement, and 357 beams.
- Forward- and inverse-planning was performed, limiting the dose to the spinal cord, brainstem, cochleae, eyes, optic chiasm, optic nerves, and oral cavity based on Timmerman recommendations [1].

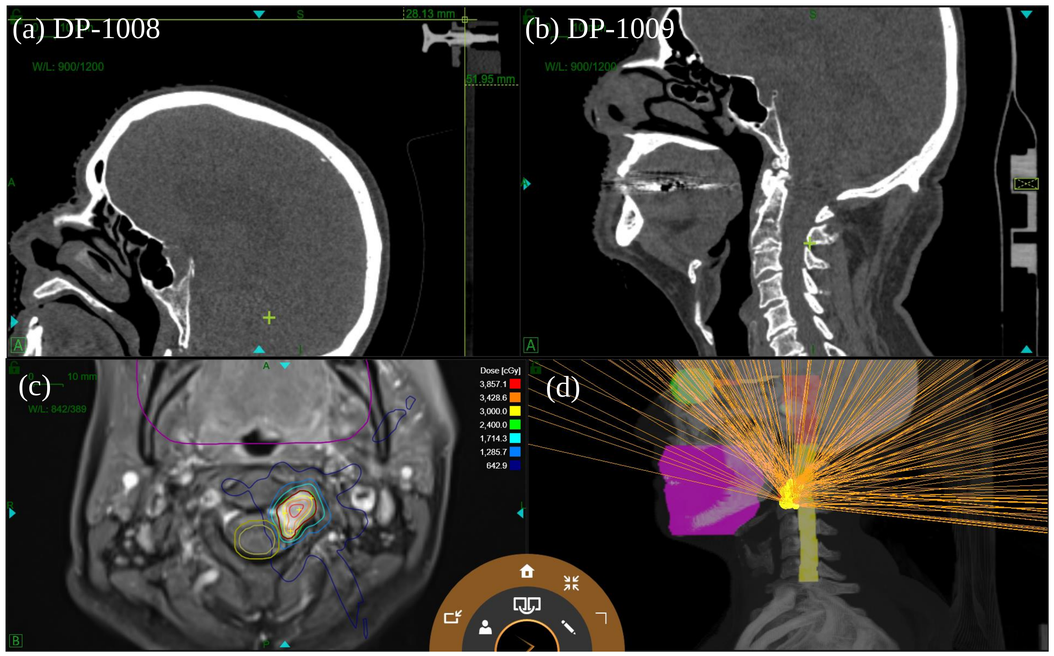

Figure 1. (a) and (b) DP-1009 upgrade which shifts the patient more superiorly, increasing the longitudinal reach by 52 mm and solid angle by 15-25%. The table origin is displayed as a green cross, corresponding to the location of the machine isocenter at home position. (c) and (d) C2-C3 spinal schwannoma patient treatment planning. Due to the increase in longitudinal reach and solid angle post DP-1009 upgrade, the anatomical treatment range of the ZAP-X increased to the C2-C3 spine.

Results

- Three-months post-treatment, patient 1 and patient 3 had complete resolution of symptoms.
- Patient 2 tolerated treatment well but expired from complications one-month after treatment due to diabetic ketoacidosis and lung cancer.

Table I. Dosimetric constraints and results for each ST patient.

Dosimetric Parameters	Patient 1 (C2-C3 Schwannoma)		Patient 2 (C1 Meningioma)		Patient 3 (C1-C2 Metastasis)	
PTV	V100% ≥ 95%:	98.16%	V100% ≥ 95%:	97.35%	V100% ≥ 95%:	96.19
	Max Dose ≤ 200%:	178.57%	Max Dose ≤ 200%:	151.52%	Max Dose ≤ 200%:	158.73
	CI (PIV/TV) ≤ 1.2-1.5:	1.158	CI (PIV/TV) ≤ 1.2-1.5:	1.167	CI (PIV/TV) ≤ 1.2-1.5:	1.066
	GI (hPIV/PIV) ≤ 3.7-4.2:	2.987	GI (hPIV/PIV) ≤ 4.3-5:	3.536	GI (hPIV/PIV) ≤ 3.445-3.771:	2.578
Spinal Cord (including medulla)	V1590cGy ≤ 0.35 cc:	0 cc	V2200cGy ≤ 0.35 cc:	0.106 cc	V2200cGy ≤ 0.35 cc:	0.153 cc
	D0.035cc ≤ 2250 cGy:	1048.2 cGy	D0.035cc ≤ 2800 cGy:	2633.4 cGy	D0.035cc ≤ 2800 cGy:	2548.5 cGy
Left Optic Nerve	V1530cGy ≤ 0.2 cc:	0 cc	V2300cGy ≤ 0.2 cc:	0 cc	V2300cGy ≤ 0.2 cc:	0 cc
	D0.035cc ≤ 1740 cGy:	63 cGy	D0.035cc ≤ 2500 cGy:	41.9 cGy	D0.035cc ≤ 2500 cGy:	146.2 cGy
Right Optic Nerve	V1530cGy ≤ 0.2 cc:	0 cc	V2300cGy ≤ 0.2 cc:	0 cc	V2300cGy ≤ 0.2 cc:	0 cc
	D0.035cc ≤ 1740 cGy:	64.9 cGy	D0.035cc ≤ 2500 cGy:	42.9 cGy	D0.035cc ≤ 2500 cGy:	119.6 cGy
Optic Chiasm	V1530cGy ≤ 0.2 cc:	0 cc	V2300cGy ≤ 0.2 cc:	0 cc	V2300cGy ≤ 0.2 cc:	0 cc
	D0.035cc ≤ 1740 cGy:	68.9 cGy	D0.035cc ≤ 2500 cGy:	41.9 cGy	D0.035cc ≤ 2500 cGy:	121.9 cGy
Left Cochlea	D0.035cc ≤ 1440 cGy:	64.7 cGy	D0.035cc ≤ 1440 cGy:	41.0 cGy	D0.035cc ≤ 1440 cGy:	645 cGy
Right Cochlea	D0.035cc ≤ 1440 cGy:	69.3 cGy	D0.035cc ≤ 1440 cGy:	42.3 cGy	D0.035cc ≤ 1440 cGy:	364.9 cGy
Brainstem (excluding medulla)	V1590cGy ≤ 0.5 cc:	0 cc	V2300cGy ≤ 0.5 cc:	0.001 cc	V2300cGy ≤ 0.5 cc:	0.035 cc
	D0.035cc ≤ 2310 cGy:	71 cGy	D0.035cc ≤ 3100 cGy:	869.7 cGy	D0.035cc ≤ 3100 cGy:	2297.6 cGy
Skin	V3100cGy ≤ 10 cc:	0 cc	V3650cGy ≤ 10 cc:	0 cc	V3650cGy ≤ 10 cc:	0 cc
	D0.035cc ≤ 3300 cGy:	751.4 cGy	D0.035cc ≤ 3850 cGy:	604.5 cGy	D0.035cc ≤ 3850 cGy:	670.3 cGy
Left Eye	Dmax ≤ 100 – 200 cGy:	65.2 cGy	Dmax ≤ 100 – 200 cGy:	185.5 cGy	Dmax ≤ 100 – 200 cGy:	61.3 cGy
Right Eye	Dmax ≤ 100 – 200 cGy:	73.3 cGy	Dmax ≤ 100 – 200 cGy:	40.8 cGy	Dmax ≤ 100 – 200 cGy:	59.5 cGy
Treatment Time/Fx	Time ≤ 60 min:	40.58 min	Time ≤ 60 min:	54 min	Time ≤ 60 min:	56.47 min

PTV:: Planning Target Volume, V100:: Prescription PTV coverage, CI:: conformity index, GI:: gradient index, V1530cGy:: volume receiving 1530 cGy, D0.035:: maximum dose to 0.035 cm^3, V2300cGy:: volume receiving 2300 cGy, V3650cGy:: volume receiving 3650 cGy, Dmax:: maximum point dose.

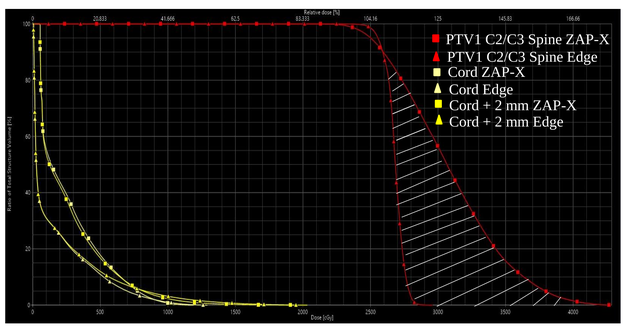

Figure 2. C2-C3 spinal schwannoma patient demonstrating potential for dose escalation with ZAP-X SRS.

Conclusion

- This case series demonstrates ZAP-X can be effectively used for the treatment of STs.
- More data is needed to show the efficacy of ZAP-X compared to other SRS modalities.

References

(1) Timmerman R. A story of hypofractionation and the table on the wall. International Journal of Radiation Oncology*Biology*Physics. 2022.