

Examining the capability of Precision, iPlan, RayStation and Monaco to satisfy the UNC treatment planning protocol of stereotactic radiosurgery for multi-lesion brain cases

Eric Schreiber¹, Michael Dance¹, Sotirios Stathakis², Anna-Laura Licon², Nikos Papanikolaou², Shiva K. Das¹, Panayiotis Mavroidis¹

¹Department of Radiation Oncology, University of North Carolina, Chapel Hill, NC
²Department of Radiation Oncology, University of Texas Health Sciences Center, San Antonio, TX

Purpose

To assess the capability of different combinations of treatment planning and delivery systems to satisfy the UNC treatment planning protocol of stereotactic radiosurgery for multi-lesion brain cases

Methods

A CT simulation scan of a patient with five brain lesions was used as a test case. Based on this anatomy, four treatment plans were developed using the following combination of planning systems and delivery machines: a) Precision-CyberKnife (Accuray); b) iPlan-Novalis (BrainLab); c) RayStation (RaySearch Laboratories)-VersaHD (Elekta); and d) Monaco-Versa HD (Elekta). For treatment planning, the UNC treatment protocol for brain multi-lesion cases was followed. However, experience and institution’s policy were used for deviations from the guidelines. The different dose distributions were examined based on their ability to satisfy the specified dose constraints but also their performance regarding dose conformity and organs at risk sparing.

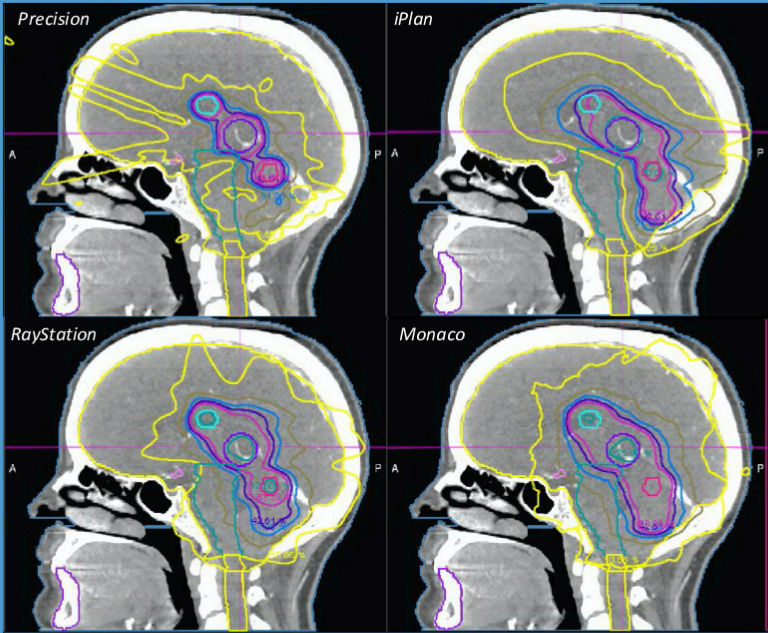


Fig 1. Illustration of the central sagittal slice of the four treatment plans created on Precision (upper left), iPlan (upper right), RayStation (lower left) and Monaco (lower right). In this slice, three of the five lesion treated in this case can be seen.

Table 1. Summary of clinical goals that were used during plan optimization for the four treatment plans. Red indicates that UNC planning criteria were not met.

Name	Clinical goals	Precision-CyberKnife	iPlan-Novalis	Raystation-Versa	Monaco-Versa
All targets	CI ≥ 0.70	0.75	0.43	0.80	0.52
PTV1	V20Gy ≥ 98%	99.2	100.0	99.9	100.0
PTV2	V20Gy ≥ 98%	99.8	100.0	99.3	100.0
PTV3	V20Gy ≥ 98%	98.2	100.0	98.9	100.0
PTV4	V20Gy ≥ 98%	99.8	99.8	98.2	97.7
PTV5	V20Gy ≥ 98%	99.9	100.0	98.2	100.0
Brain (cm ³)	V12Gy < 10cc	21.1	47.1	32.5	56.3
Brainstem (cm ³)	V10Gy < 0.5cc	0.3	0.1	0.4	0.7
Brainstem (Gy)	D0.035cc < 15Gy	14.2	13.4	14.9	15.0
Chiasm (cm ³)	V8Gy < 0.2cc	0.0	0.0	0.0	0.0
Chiasm (Gy)	D0.035cc < 10Gy	3.1	1.4	1.0	4.2
Optic_Nerves (cm ³)	V8Gy < 0.2cc	0.0	0.0	0.0	0.0
Optic_Nerves (Gy)	D0.035cc < 10Gy	2.5	1.8	0.9	3.0
Cochlea_Lt (Gy)	D0.035cc < 9Gy	1.8	0.6	1.2	3.7
Cochlea_Rt (Gy)	D0.035cc < 9Gy	2.8	2.6	1.1	2.3

Name	Volume (cm ³)	Precision			iPlan			Raystation			Monaco		
		D _{99%}	D _{mean}	D _{1%}	D _{99%}	D _{mean}	D _{1%}	D _{99%}	D _{mean}	D _{1%}	D _{99%}	D _{mean}	D _{1%}
Targets													
PTV1 (7mm)	0.16	18.8	24.1	27.4	19.5	25.8	30.3	20.0	21.3	22.2	19.7	21.9	23.3
PTV2 (9mm)	0.56	18.9	24.0	27.6	20.1	24.4	26.9	19.7	23.7	27.2	20.2	22.3	24.0
PTV3 (12mm)	0.90	19.3	24.0	27.3	20.3	25.5	28.8	19.9	23.4	26.6	20.0	22.8	24.7
PTV4 (20mm)	4.08	20.4	24.8	27.4	18.1	27.5	32.5	15.8	23.7	28.4	19.0	23.5	25.8
PTV5 (15mm)	2.05	20.5	25.0	27.4	20.0	24.4	27.3	19.7	24.4	28.7	20.6	22.8	24.9
OARs													
Brain	1246.09	0.2	2.7	18.4	0.2	3.7	23.2	0.2	3.1	18.1	0.5	4.1	20.6
Brainstem	25.09	0.9	3.5	10.2	0.5	1.7	7.5	1.8	3.8	8.2	2.5	5.0	11.8
Chiasm	0.27	1.8	2.6	3.9	1.0	1.2	1.7	0.7	0.8	1.2	3.3	3.9	4.7
Optic_Nerves	0.40	0.2	0.7	2.9	0.5	1.1	1.9	0.5	0.7	0.9	0.7	1.6	3.3
Cochlea_Lt	0.16	1.1	1.6	2.4	0.4	0.6	0.8	0.9	1.0	1.2	3.2	3.5	4.0
Cochlea_Rt	0.10	2.4	2.7	3.2	2.2	2.6	2.0	1.0	1.1	1.1	1.7	2.2	2.6

Table 2. Summary of different dosimetric metrics for the four treatment plans. D_{99%}: minimum dose to the 99% of the target/organ, D_{mean}: mean dose, D_{1%}: minimum dose to the hottest 1% of the target/organ.

Results

Precision and RayStation had conformity index values of 0.75 and 0.80 satisfying the clinical goal (≥0.70), whereas iPlan and Monaco had 0.43 and 0.52. Four of the plans covered all five PTVs as prescribed ($V_{20Gy} \geq 98\%$) with the exception of Monaco (one lesion had 97.7%). All the plans failed to satisfy the constraint of $V_{12Gy} < 10cc$ for brain minus PTVs (Precision: 21.1cc, iPlan: 47.1cc, RayStation: 32.5cc, Monaco: 56.3cc). All the plans satisfied the constraint of $D_{0.035cc} < 15Gy$ for brainstem (Precision: 14.2Gy, iPlan: 13.4Gy, RayStation: 14.9Gy, Monaco: 15.0Gy). Sample isodose distributions are shown in Figure 1. Full results are shown in Table 2.

Discussion and Conclusions

A direct, strict comparison of the different treatment plans is out of the scope of this study. The focus is to validate whether all the examined combinations of planning system and radiotherapy unit can provide clinically acceptable plans using a very challenging clinical case and a tight clinical protocol.

None of the plans satisfied all the requirements of the clinical protocol (Table 1). However, their deviations were within the range of clinical acceptance. All the plans were comparable in terms of quality. Plan differences may stem from the planners’ choices balancing the level of target coverage against sparing brainstem and brain, as opposed to the platform used (combination of planning system – machine).