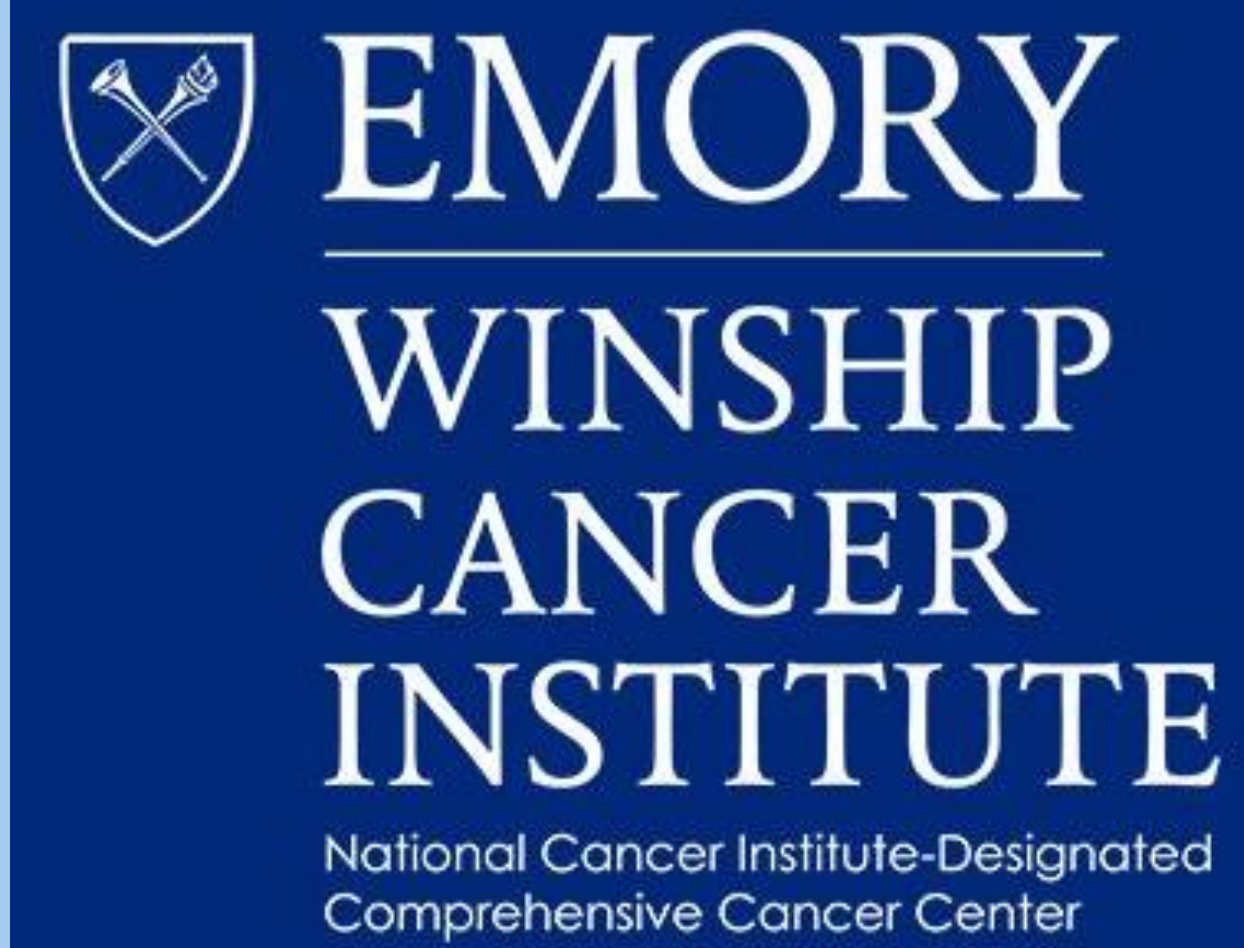




Beam Geometry Optimization and Convergence Mode Evaluation for Knowledge-Based Planning of Hippocampal Avoidance Whole-Brain Radiotherapy: A Cross-Platform Study with Quantitative Scorecard Assessment

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INTRODUCTION

Background:

- Hippocampal avoidance whole-brain radiotherapy (HA-WBRT) is used in the treatment of brain metastases to help preserve cognitive function by limiting dose to the hippocampi
- Volumetric modulated arc therapy (VMAT) is frequently used due to its ability to achieve conformal dose distributions
- However, HA-WBRT planning is challenging because the centrally located hippocampi require rapid dose fall-off to achieve adequate sparing while maintaining whole-brain target coverage.

Purpose: To evaluate the dosimetric impact of a four-arc hybrid geometry (4A-HG) and different convergence mode (CM) settings for HA-WBRT using a knowledge-based planning (KBP) workflow across two Varian platforms: Halcyon and Edge.

METHODS

- Twenty HA-WBRT patients were replanned (30 Gy in 10 fractions) using a KBP model
- Four arc configurations were evaluated:
 - Three open-field geometries with different numbers of arcs (2A, 3A, and 4A)
 - 4A-HG: two full-field arcs for global target coverage and two partial-field arcs with superior and inferior MLC/jaw restrictions near the hippocampal region to improve hippocampal sparing
- Each configuration was tested with three convergence mode settings (Off, On, and Extended), on Halcyon and Edge platforms
- 24 plans per patient; plans were normalized so that 95% of planning target received 100% of prescription dose
- Dosimetric analysis using RTOG 0933 metrics, as well as a custom scorecard incorporating PTV D100% and the Paddick conformity index (PCI)
- Quality assurance was performed for the five highest-monitor-unit (MU) plans on each platform

ACKNOWLEDGEMENTS

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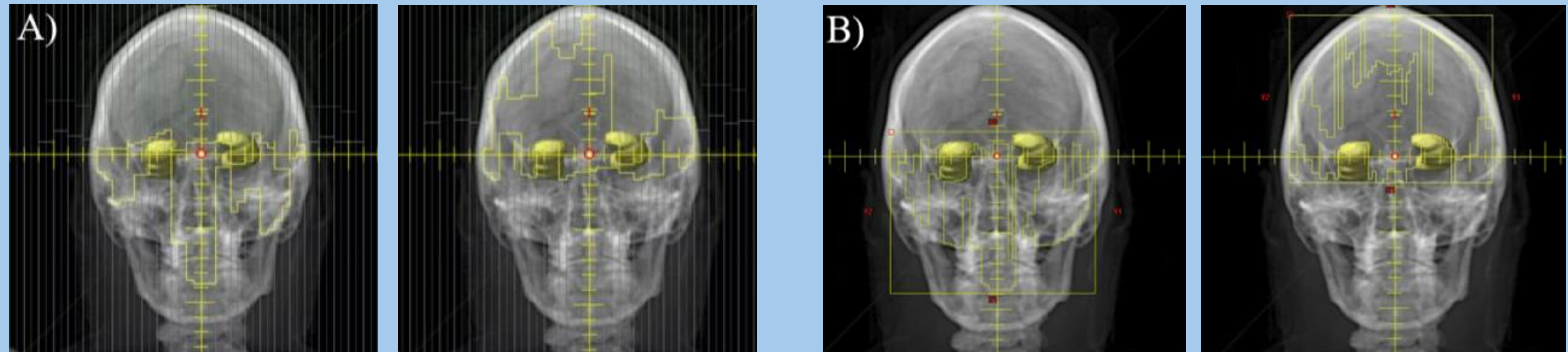


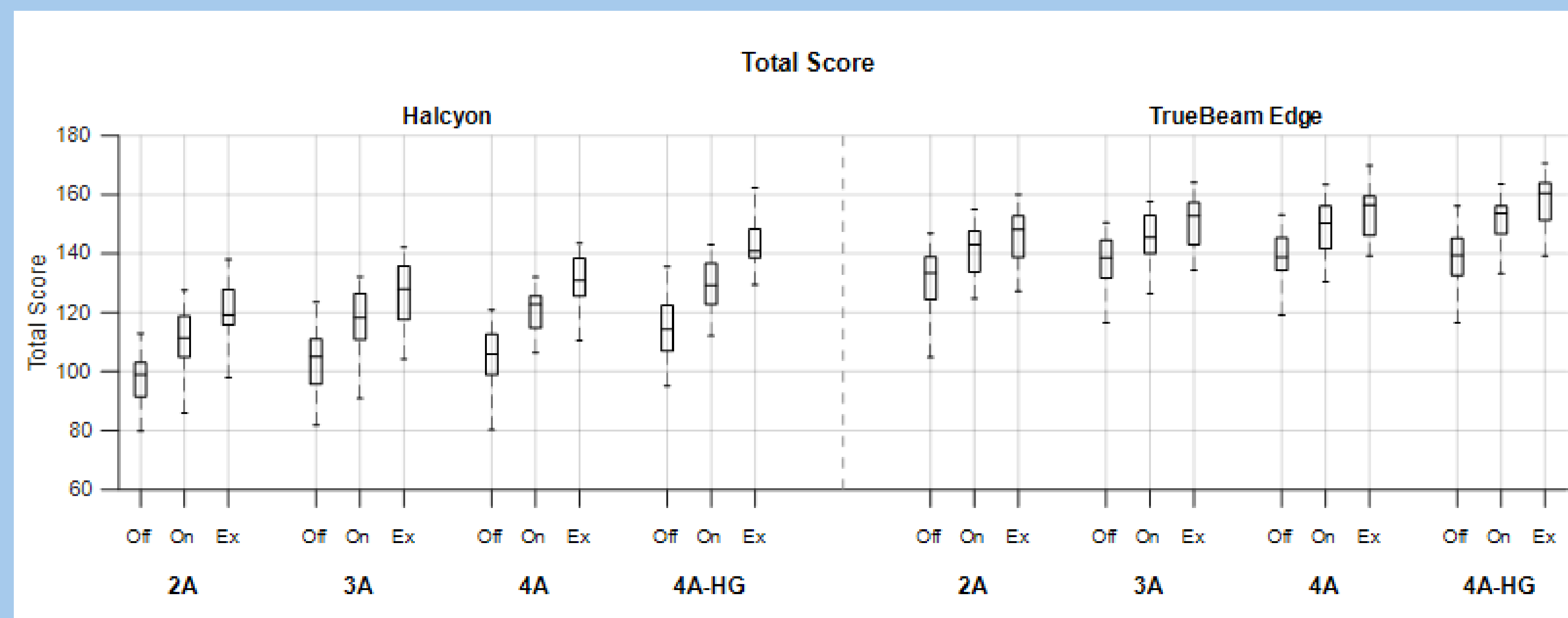
Figure 1. The two partial fields of 4A-HG arc configuration illustrating field truncation near the hippocampus PRV (yellow) to improve sparing. A) Halcyon: inferior and superior field extents limited at the edge of the hippocampus PTV using the “limit MLC” feature; B) Edge: inferior and superior field extents limited at the edge of the hippocampus PTV using jaws

RESULTS

Table 1. Results of selected dosimetric metrics

		Halcyon			Edge		
Metrics	Arc configuration	CM “Off”	CM “On”	CM “Extended”	CM “Off”	CM “On”	CM “Extended”
PTV D100% (Gy)	2A	18.482 ± 0.906	18.672 ± 1.201	18.948 ± 1.121	19.206 ± 1.265	19.433 ± 1.224	19.613 ± 1.254
	3A	18.470 ± 1.280	18.668 ± 1.111	18.880 ± 1.232	19.082 ± 1.267	19.343 ± 1.170	19.402 ± 1.212
	4A	18.384 ± 1.230	18.492 ± 1.169	18.787 ± 1.107	19.005 ± 1.212	19.432 ± 1.174	19.498 ± 1.222
	4A-HG	18.740 ± 1.108	19.028 ± 1.116	19.416 ± 1.427	19.507 ± 1.022	20.011 ± 1.202	20.170 ± 1.208
PCI	2A	0.913 ± 0.007	0.921 ± 0.006	0.923 ± 0.007	0.928 ± 0.006	0.934 ± 0.005	0.936 ± 0.005
	3A	0.921 ± 0.007	0.927 ± 0.007	0.931 ± 0.006	0.935 ± 0.006	0.939 ± 0.005	0.942 ± 0.004
	4A	0.924 ± 0.007	0.930 ± 0.006	0.934 ± 0.005	0.937 ± 0.005	0.941 ± 0.004	0.943 ± 0.004
	4A-HG	0.929 ± 0.007	0.933 ± 0.009	0.940 ± 0.005	0.937 ± 0.005	0.941 ± 0.004	0.944 ± 0.004
Hippocampus Dmax (Gy)	2A	15.545 ± 0.885	14.863 ± 0.815	14.446 ± 0.896	13.577 ± 0.762	13.157 ± 0.685	12.945 ± 0.661
	3A	15.623 ± 1.028	14.913 ± 1.015	14.392 ± 0.962	13.711 ± 0.870	13.150 ± 0.726	12.834 ± 0.673
	4A	15.769 ± 0.950	14.916 ± 0.885	14.323 ± 0.921	13.574 ± 0.759	13.054 ± 0.639	12.744 ± 0.521
	4A-HG	15.144 ± 0.942	14.370 ± 0.838	13.662 ± 0.813	13.508 ± 0.796	12.863 ± 0.690	12.566 ± 0.705

Figure 2. Boxplot of scorecard results



- 4A-HG outperformed the other geometries for target coverage and hippocampal sparing
- Highest mean PCI values achieved with 4A-HG: 0.940 on Halcyon and 0.944 on Edge.
- Using Extended CM, 4A-HG produced the lowest hippocampal Dmax on both platforms
 - vs 2A: Halcyon 14.446 → 13.662 Gy; Edge 12.945 → 12.566 Gy
- Best overall scorecard result: 157/184 with TrueBeam Edge + 4A-HG + Extended CM.
- Higher MU did not compromise deliverability; all high-MU plans passed institutional patient-specific QA

CONCLUSIONS

- The 4A-HG configuration improved HA-WBRT plan quality by enhancing target coverage and hippocampal sparing across both platforms
- While more extensive CM settings further increased quality, they required longer optimization times
- These results support the clinical use for VMAT-based HA-WBRT

REFERENCES

