Hippocampal Sparing Whole Brain: RapidPlan Model Training Process

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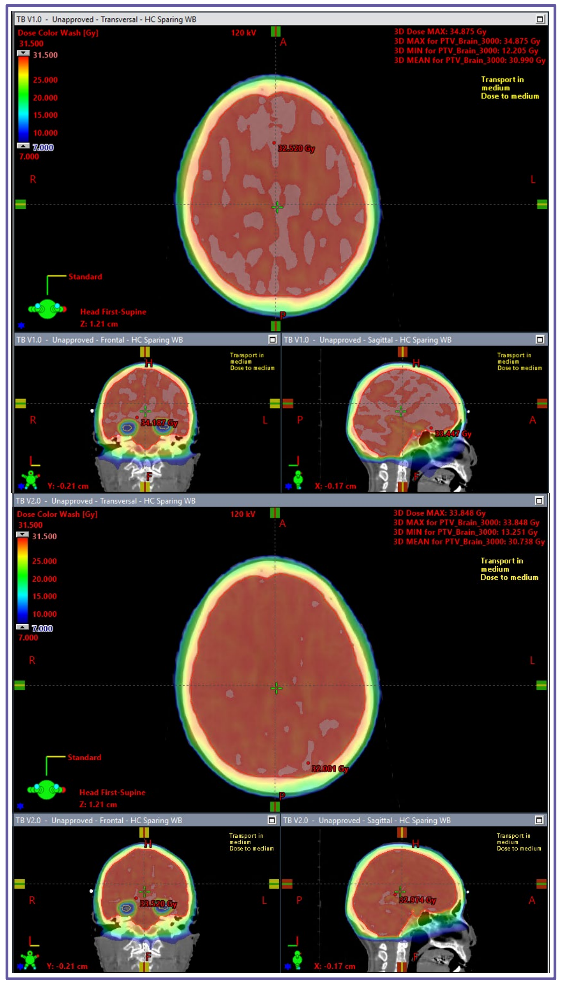
Background

Creating hippocampal sparing whole brain (HSWB) treatment plans is time consuming and can have high variability in desired plan quality metrics. Knowledge Based Planning (KBP) is a solution that can expedite the treatment planning process while improving dosimetric standardization across HSWB plans. RapidPlan™ is a commercial implementation of KBP (Varian Medical Systems, Palo Alto, CA). In 2016, a Hippocampal Sparing Whole Brain Model Version 1.0 (HSWBv1) was made publicly available.[2] From this model, we developed a new HSWB KBP model (HSWBv2) following a similar recursive training process. This new model placed further emphasis on improving hippocampal sparing, homogeneity, and conformity. A newly developed, comprehensive scorecard with additional points and metrics was used to quantify the improvements made throughout the training process.

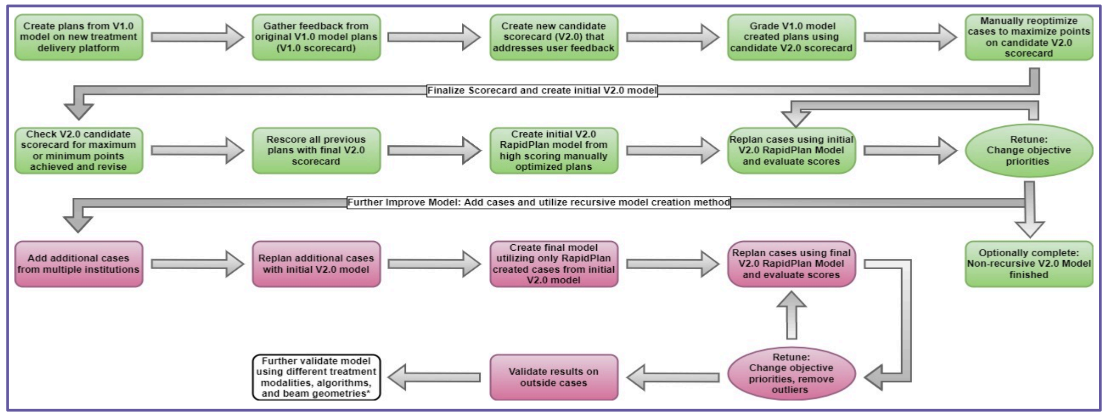
Figure 1: Isodose Comparison of HSWBv1 (Top) vs HSWBV2 (Bottom)



Methods

50 anonymized whole brain DICOM data sets were obtained from patients treated per NRG-CC001 protocol. All cases were ultimately replanned to 30Gy in 3Gy fractions with 6X-FFF energy on a Varian Halcyon with SX2 MLC mode using VMAT. The arcs had alternating clockwise and counterclockwise gantry rotations with collimator positions set at 315, 0, 45 and 90 degrees. The coplanar arcs had 359.8 degrees of arc rotation and were positioned with isocenter located in the center of the target.

Figure 2: Flowchart of HSWBV2 Model Creation, Training, and Validation



The 20 plans used in HSWBv1 model were the starting point for this work. The cases were reoptimized using HSWBv1 with Halcyon and evaluated with a new scorecard (evolved from the original 2016 scorecard criteria) using a publicly available PlanScoreCard tool.[3] Multiple scorecard candidates were tested with additional structures and metrics added/edited. The new scorecard was modified until the dosimetric gains from manually reoptimizing the plans with higher priorities were captured. These reoptimized, improved plans were then used as the initial training set for the first iteration of the HSWBv2 model. The optimization objectives were then retuned to produce dosimetric results that maximized the total points on the scorecard. More cases were then added, and a recursive model creation process was employed to ensure the final HSWBv2 training set consisted, exclusively, of plans generated from the initial HSWBv2 model. Evaluating the plan scores at each step in the process informed multiple iterations of further re-tuning the optimization objective set. After the additional cases were added, geometric outliers became apparent. These outlier cases were then omitted from the final HSWBv2 training set resulting in a final model trained with 42 cases.

Figure 3: Average total score of final 42 cases during each step of mode training

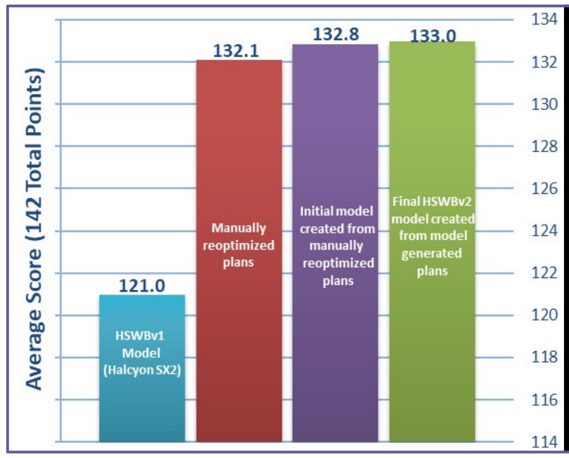
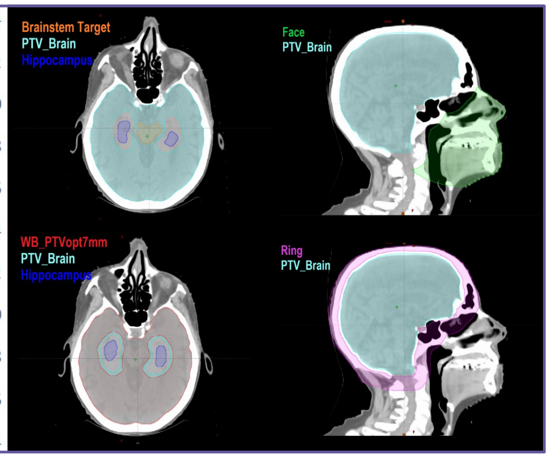


Figure 4: Example of optimization structures used for planning



Results

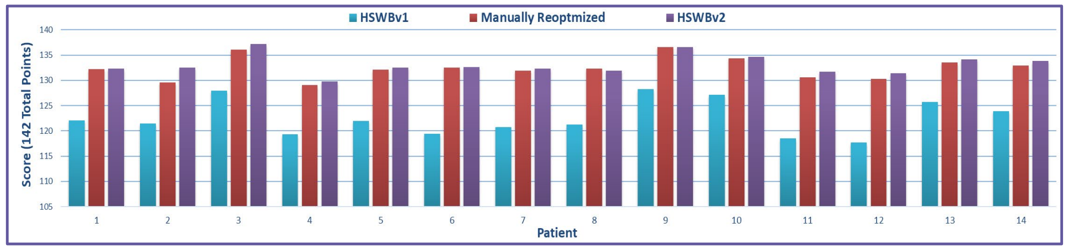
The final KBP model resulted in producing very consistent, high-quality plans featuring tight DVH prediction bands which allowed for aggressive hippocampal sparing optimization objectives to be used. This was enabled through both a recursive model training process and a fine-tuned score card. Dosimetric scorecards are useful as an objective quantitative measure of plan quality metrics (PQM) which can be referenced throughout multiple iterations of optimization objective tuning.[5]

Figure 3: Example Version 2.0 scorecard; validation case score 131.4/142

Conclusions

This research intends to assist clinicians in developing and implementing their own robust KBP models by using scorecards and a recursive training process. This KBP model is publicly available along with further information on how to implement the model in a clinical description document.[4]

Figure 6: Plan score comparison throughout model creation process (First 14 plans)



Reference

(1) Liu, Hefei et al. "RapidPlan hippocampal sparing whole brain model version 2-how far can we reduce the dose?." *Medical dosimetry : official journal of the American Association of Medical Dosimetrists*, S0958-3947(22)00039-5. 2 May. 2022, doi:10.1016/j.meddos.2022.04.003.

(2) Magliari, Vanessa et al. "Hippocampal sparing whole brain: Rapid Plan Model Following the NRG-CC001 Protocol". AAMD conf poster present. 2017; (Published online available at:) https://medicalaffairs.varian.com/download/PosterPresentationAAMD2017RapidplanHCSWB.pdf

(3) https://github.com/Varian-Innovation-Center

(4) https://medicalaffairs.varian.com/wholebrain-hippocampalsparing-vmat2

(5) Nelms BE, Robinson G, Markham J et al. Variation in external beam treatment plan quality: An inter-institutional study of planners and planning systems. Pract Radiat Oncol. 2012; 2: 296-305 https://doi.org/10.1016/j.prro.2011.11.012