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Evaluation of Knowledge-Based Planning Model in Head and Neck Cancer Using Volumetric Modulated Arc Therapy on a Halcyon System

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ABSTRACT

This study evaluated whether a RapidPlan (RP) model trained with head and neck cancer plans on a conventional linac using 6 MV flattening filter beams could generate high-quality VMAT plans for Halcyon using 6 MV flattening filter-free beams. The RP model was trained using clinically approved VMAT plans and validated with independent patients. Dosimetric performance and planning efficiency were compared between TrueBeam and Halcyon plans. TrueBeam provided significantly better dose homogeneity for the target. However, Halcyon significantly reduced the mean dose to the bilateral parotid glands and oral cavity without increasing the maximum dose to serial organs at risk. Both systems required less than 30 minutes for a single optimization, and all Halcyon plans achieved gamma passing rates (3%/2 mm) above 99%. A conventional linac-trained RP model successfully generated high-quality VMAT plans for Halcyon with consistent plan quality and efficient planning despite differences in beam characteristics and MLC design.

INTRODUCTION

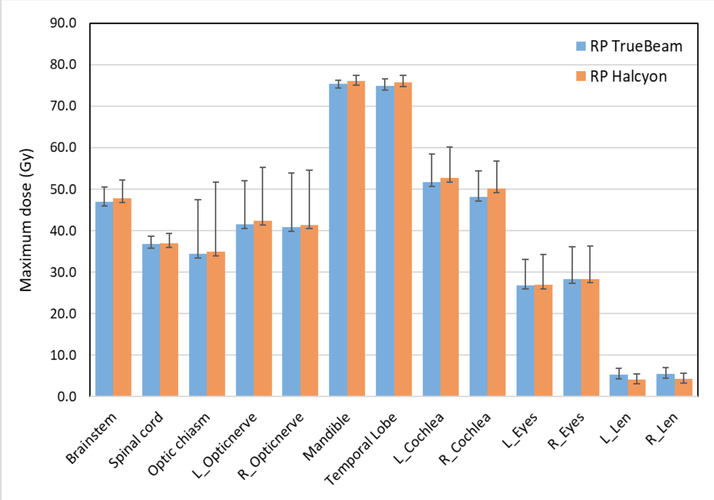
Knowledge-based planning (KBP) optimization engine, RapidPlan (RP), was utilized to potentially reduce variability of plan quality and decrease optimization times. When implementing a new treatment delivery system such as the Halcyon, planners may require considerable time to generate enough treatment plans to establish a dataset suitable for training a new KBP model. This study aimed to evaluate the performance of a KBP model trained on head and neck cancer treated with a conventional linac using 6 MV flattening filter (FF) beams, which can effectively generate high-quality volumetric modulated arc therapy (VMAT) plans for the Halcyon with 6 MV flattening filter-free (FFF) beams.

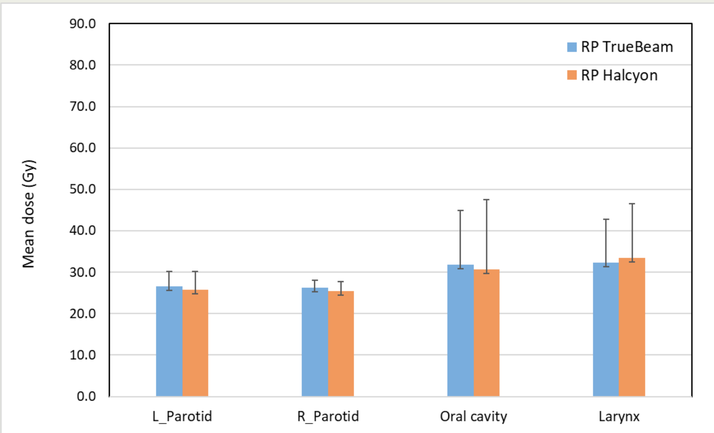
METHODS AND MATERIALS

The RP model was trained using dosimetric and geometric data from 60 patients with head and neck cancer. All plans were clinically approved and had been used in previous treatments with a conventional linac with three targets at dose levels of 54, 60, and 70 Gy in 33 fractions from 2-3 arcs. To assess the applicability of the model for Halcyon, an independent cohort of 18 patients not included in the training dataset was used to evaluate. The dosimetric outcomes and planning efficiency of VMAT plans produced on TrueBeam (RP_TB) were compared with those produced on Halcyon (RP_Hal).

RESULTS

The result showed that the RP_TB plans demonstrated significantly higher dose homogeneity in the target at dose 70 Gy compared with the RP_Hal plans. However, RP_Hal plans significantly reduced the mean dose to parallel organs, including left and right parotid glands and oral cavity, compared to RP_TB plans, while the maximum dose to serial organs did not increase significantly (Figure 1). The average planning time for both RP_Hal and RP_TB plans with single optimization was less than 30 minutes. The pre-treatment verifications for RP_Hal plans with a gamma index (3%, 2mm) higher than 99% in all cases.





DISCUSSION

This study shows that the RP model is not limited to the treatment delivery system used for model training. Even though TrueBeam and Halcyon have different MLC designs and beam characteristics, the model still produced clinically acceptable plans on both systems. The improved sparing of the parotid glands and oral cavity with Halcyon may be related to its dual-layer MLC, while the small difference in target dose homogeneity is more likely due to machine-specific delivery characteristics rather than limitations of the model. These results support the feasibility of transferring an existing RP model between Varian treatment systems, reducing the need for machine-specific model development and facilitating the rapid clinical deployment of Halcyon.

CONCLUSIONS

The KBP model achieved greater consistency and enhanced plan quality for head and neck cancer cases. Moreover, the KBP model trained with a conventional linac can provide high-quality VMAT plans for Halcyon, despite differences in beam energy and collimator design.

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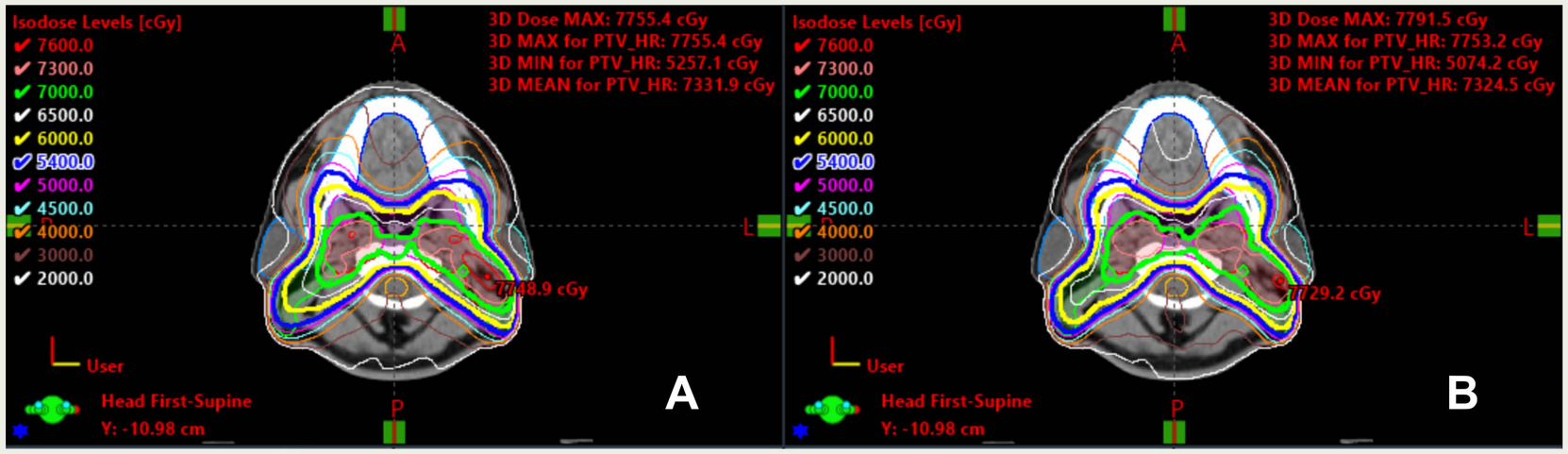

Figure 1. Dose distribution comparison between the RP_TrueBeam (A) and RP_Halcyon (B).

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