# Novel Multiple-Isocentric Automatic Planning Approach for Craniospinal Irradiation

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## INTRODUCTION

Craniospinal irradiation (CSI) is an essential component in the curative treatment of primary central nervous system tumors such as medulloblastoma, brain tumors at risk of leptomeningeal fluid dissemination [1-3]. Conventionally, CSI treatments are delivered via a three-dimensional conformal radiation therapy (3D-CRT) technique. This approach results in dose inhomogeneity, especially in the region of field junction [4-6]. Recently, tremendous advances has been made in radiotherapy technology, the modern radiotherapy modalities including intensity modulated radiation therapy (IMRT), volumetric modulated arc therapy (VMAT), tomotherapy, and proton pencil beam scanning therapy are increasingly being examined as a possibility for CSI [7], which allow for a more homogeneous and conformal dose distribution throughout the planning target volume (PTV) while better sparing of some organs at risk with respect to the traditional 3D-CRT method.

However, treatment planning for CSI remains technically challenging and extremely labor-intensive due to the ultra-long target volume, complex anatomic features and organ at risk (OAR) shape variability. Manual optimization parameter tuning and re-optimization is inefficient and very time-consuming. Recently, the data-driven technique has accumulated popularity in that can help automate the planning process, various automated planning techniques including Rapid-Plan (Varian Medical Systems, Palo Alto, CA) , Multi-Criteria Optimization (RaySearch Laboratories, Stockholm, Sweden) , and Pinnacle3 Auto-plan (Philips Medical Systems, Best, The Netherlands) [8-10] have been explored to speed up the planning process using clinical plans templates, and reduce planner variability and drastically improve the planning quality and efficiency of the treatment plans. The purpose of this work is to develop an innovative multiple isocentric automatic planning technique (MultiIsoAP) for CSI.

## AIM

As the complexity of treatment involving multiple isocenters, large target volume, complex anatomic features and OARs shape variability. Treatment planning for CSI remains technically challenging and extremely labor-intensive. In this work, we aimed to develop an innovative multiple isocenters induced progressive optimization based automatic planning method for CSI.

## METHOD

Fifteen medulloblastoma patients selected from our institution were retrospectively replanned with MultiIsoAP (36 Gy in 20 fractions) and compared to manually volumetric modulated arc therapy (mpVMAT) which consisted of multiple isocenters and overlapping arcs. For these patients, manually planned intensity-modulated radiotherapy (mpIMRT) were also generated in addition to the VMAT based treatment plans. In summary, the implementation of the presented MultiIsoAP approach can be described as following steps.

A. The previous beam-setup and preparation procedures of MultiIsoAP were identical with VMAT based CSI technique except for automatically chosen-jaw.
B. The dynamic MLCs and jaws of mpVMAT were all free moving. For the MultiIsoAP, the longitudinal-jaws from cranial-spinal junction and spinal-spinal junction were manually fixed and suitably adjusted to acquire the optimal overlaps.
C. Subsequently, the progressive optimization based Pinnacle auto-planning engine was induced to automatically adapt objectives, constraints, and auxiliary structures during optimization.
D. Quantitative evaluations of dose-volume histogram parameters for PTV and OARs, and conformity index (CI) and homogeneity index (HI) for the target were all computed and compared.
E. Statistical differences among different treatment modalities were analyzed with paired Wilcoxon signed-rank test.

## RESULTS

All treatment plans met the clinical requirements. Evaluations showed a superior plan quality for MultiIsoAP compared to mpVMAT and mpIMRT. The dose distributions of one patient with corresponding cumulative DVHs for both PTV and OAR are shown in Figure 1 and Figure 2. The target coverage presented with V95% for mpIMRT, mpVMAT and MultiIsoAP were 95.41% ± 1.36%, 95.68% ± 2.61%, and 96.45% ± 0.65%, respectively. The homogeneity and conformity of MultiIsoAP were significantly improved among the three treatment modalities especially for the adjacent field areas. The average active operator time reduced from (86.8±15.2) for mpIMRT and (64.8 ± 11.0) for mpVMAT to (29.8 ± 8.1) min for MultiIsoAP. mpVMAT spared better on Lenses-D1, optic nerves, optic chiasm, Lung-V20, and kidneys-Dmean compared with mpIMRT, while it was appreciably increased compared to MultiIsoAP. MultiIsoAP and mpVMAT resulted in significant reduction for total MUs by 42.6% and 34.7% compare to mpIMRT. No statistic difference was observed with respect to other OARs.

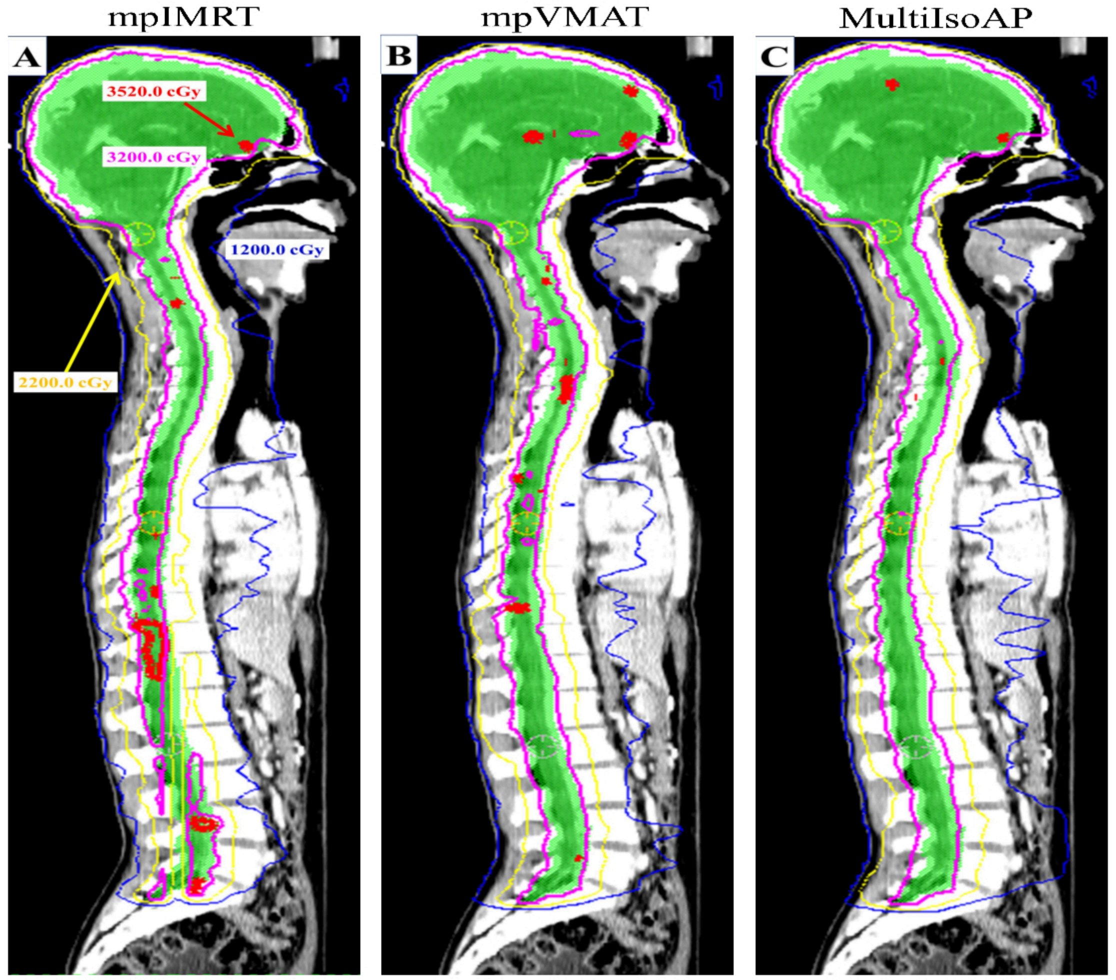


Figure 1 The sagittal dose distributions in one representative patient of for the three treatment plans: A) mpIMRT, B) mpVMAT, C) MultiIsoAP

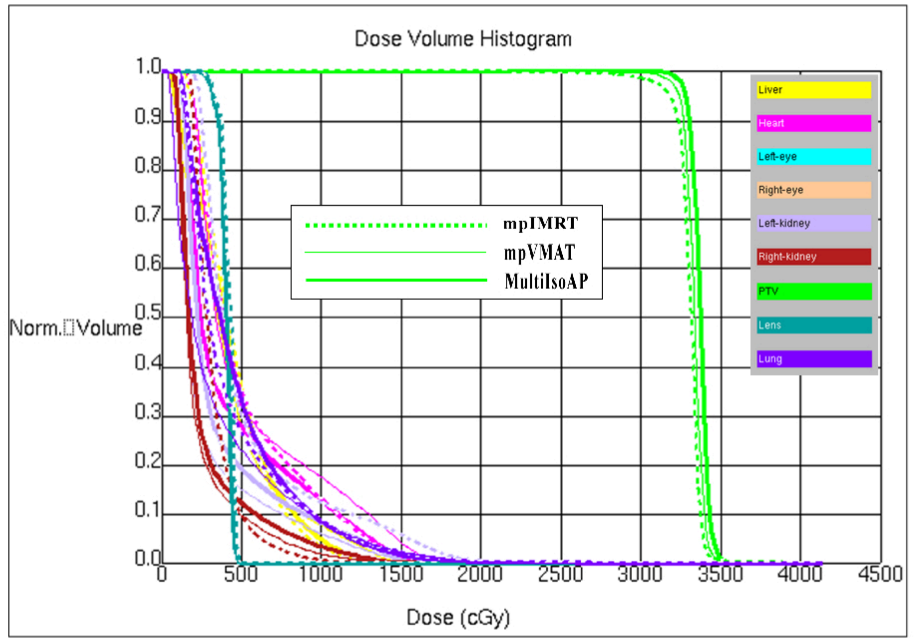


Figure 2 The comparison of DVHs for the PTV and organs at risk for the three method

## CONCLUSIONS

The proposed MultiIsoAP efficiently generate acceptable treatment plans for CSI without dose escalation and overall superior to manual planning, which could potentially be applied for other multi-metastatic cancers.

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