Automating the Treatment Planning Process for 3D-Conformal Pediatric Craniospinal Irradiation Therapy

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Abstract

Purpose: Pediatric patients with medulloblastoma in LMICs are most treated with 3D conformal photon craniospinal irradiation (CSI), a time-consuming, complex treatment to plan, especially in resource-constrained settings. Therefore, we developed and tested a 3D conformal CSI autoplanning tool for varying patient lengths. Methods and Materials: Autocontours were generated with a deep learning model trained:tested (80:20 ratio) on 143 pediatric medulloblastoma CT scans (patient ages, 2-19 years, median=7 years). Using the verified autocontours, the autoplanning tool generated 2 lateral brain fields matched to a single spine field, an extended single spine field, or 2 matched spine fields. Additional spine sub-fields were added to optimize the corresponding dose distribution. Feathering was implemented (yielding 9-12 fields) to give a composite plan. Each planning approach was tested on 6 patients (ages, 3-10 years). A pediatric radiation oncologist assessed clinical acceptability of each autoplan.

Results: The autocontoured structures’ average Dice similarity coefficient ranged from 0.65-0.98. The average V95 for the brain/spinal canal for single, extended, and multi-field spine configurations was 99.9±0.06%/99.9±0.10%, 99.9±0.07%/99.4±0.30%, and 99.9±0.06%/99.4±0.40%, respectively. The average maximum dose across all field configurations to the brainstem, eyes (L/R), lenses (L/R) and spinal cord were 23.7±0.08 Gy, 24.1±0.28 Gy, 13.3±5.27 Gy, 25.5±0.34 Gy, respectively (prescription=23.4 Gy/13 fractions). Of the 18 plans tested, all were scored as clinically acceptable as-is or clinically acceptable with minor, time-efficient edits preferred or required. No plans were scored as clinically unacceptable. Conclusion: The autoplanning tool successfully generated pediatric CSI plans for varying patient lengths in 3.50 ± 0.4 minutes on average, indicating potential for an efficient planning aid in resource-constrained settings.

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Automatically Contour Structures

Set Isocenters and Define Target Volumes

Generate and Conform Brain and Spine Treatment Fields

Prescribe and Optimize Dose

Feather and Generate Composite Plan
Brain Isocenter

Spine Isocenter Configurations

Isocenter placement consistent across 3 configurations

Measure Spine Length (X)

Single

Extended

Multiple

X = extended SSD max field

Before

Spine Sub-Field Workflow

After

1. 95% isodose → RDI

2. Extract volume of 95% isodose that is a 0.5 cm anterior of the canal

3. Generate sub-field around extracted over-coverage volume and weight 1% of primary beam

4. Recalculate dose, repeat steps 1-3 and increase sub-field weighting until over-coverage volume is no longer minimized or maximum beam weighting has been reached (10%)

Contouring Model

- Adult
- Pediatric

Structure

Structure