# Evaluating the Accuracy of Atlas-based Auto-segmentation for Pediatric Craniospinal Irradiation


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## 1. INTRODUCTION

Craniospinal irradiation (CSI) is an important method used to treat pediatric patients with central nervous system tumors.[1] Prior to treatment, dosimetrists use the planning CT to manually contour selected target and normal tissue structures. These structures are then approved by a radiation oncologist.

Atlas-based auto-segmentation is a promising method for radiation therapy contouring, [2,3,4,5] especially when used for patients with large number of structures, such as those who require CSI.

To our knowledge, no study has been performed to explore the use of an atlas-based auto-segmentation tool to generate contours for pediatric patients planned for CSI.

## 2. PURPOSE

To evaluate the accuracy of a commercial atlas-based auto-segmentation tool for pediatric patients who require CSI treatment planning.

## 3. METHODS

- Anatomical changes for children and adolescents and clinical case distributions were carefully considered during atlas construction. A total of 111 pediatric CSI patients were divided into 3 age groups : age 3-8 years (48 patients), 9-14 years (39 patients) and 15-21 years (24 patients). For each patient, 18 structures were manually contoured on planning CT by dosimetrists and approved by radiation oncologists were imported into the atlas library. Structures included those presented in Figure 2.
- The CT images were acquired for clinical purposes using the following protocol: A Spectral CT scanner, with a 0.98 mm pixel size,1-2 mm slice thickness and 120 KV. The number of slices depended on the age of the child (300-1000 slices). Older children required more slices.

## 3. METHODS (CONTINUED)

- For testing atlas accuracy, contours for each patient were auto-segmented by atlas and compared with manual contours without including the subject in the age-dependent atlas library.
- A statistical validation between manual and auto-segmented contours was performed by using the Dice similarity coefficient (DSC).

## 4. RESULTS

*4.1: The correlation between structure volume and DSC for all subjects*

- Structure volume and DSC were moderately correlated ($R^2$ = 0.51).
- Structure volumes ≥ 550 cc had average DSC values ≥ 0.95 (Figure 1).
- The atlas segmentation tool performed better for larger structures.

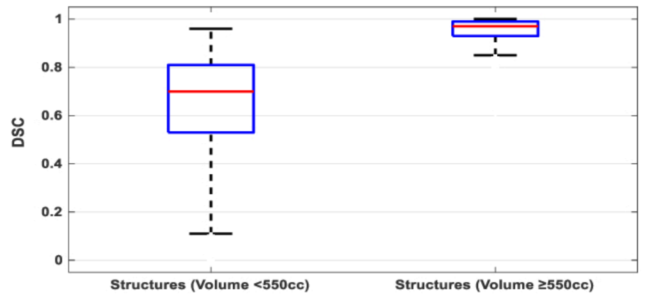


Figure 1: Whisker box plots of DSC for structures <550 cc (left) and structures ≥550 cc (right). The central red line in the box represents the median. The bottom and top edges of the box indicate the 25th and 75th percentiles, respectively. The whiskers extend to the most extreme data points not considered outliers.

*4.2: Atlas performance for different structures*

- Structure volume was not the only determinant factor for atlas performance. Small structures with well-defined shapes or high contrast compared to surrounding structures such as the eyes (mean volume =7.06 cc) achieved a high DSC (mean=0.84), (Figure 2).
- Structures with the highest mean DSC were the CTV brain (mean volume = 1415 cc, mean DSC = 0.99), followed by lungs and CTV Spine.
- The smallest mean DSCs were calculated for optic chiasm (mean volume = 0.58 cc, mean DSC = 0.37), and optic chiasm (mean volume = 0.59 cc, mean DSC = 0.56).

## 4. RESULTS (CONTINUED)

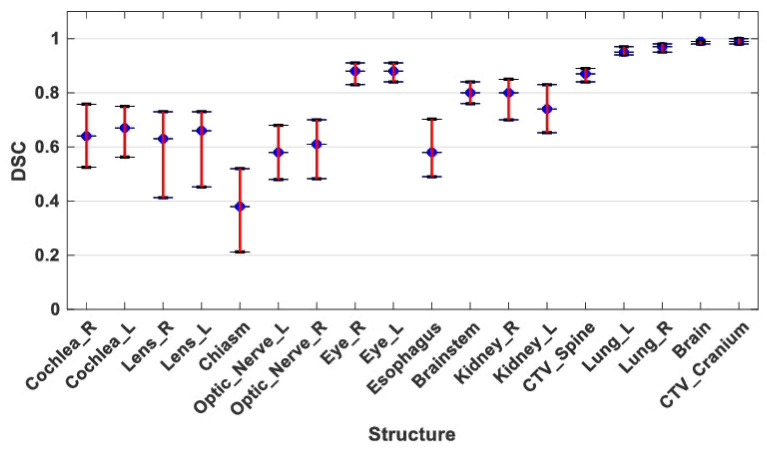


Figure 2: Whisker plots of DSC for 18 structures. Structures are arranged in ascending order of average volume from left to right. The blue bullets represent the median DSC. The lower and upper whiskers represent the 25th and 75th percentiles, respectively.

*4.3: Atlas performance based on age*

- There was no significant difference ($p$= 0.1) in mean DSC comparing the 3-8 age group (DSC = 0.78) and the 9-14 age group (DSC = 0.75).
- The 15-21 age group, which included the smallest number of subjects, had a significantly lower mean DSC (0.71; $p$ < 0.01). Figures 3 and 4 show the structures that were manually contoured by a dosimetrist superimposed on the structures that were created by the atlas segmentation tool for three patients, one from each patient group.

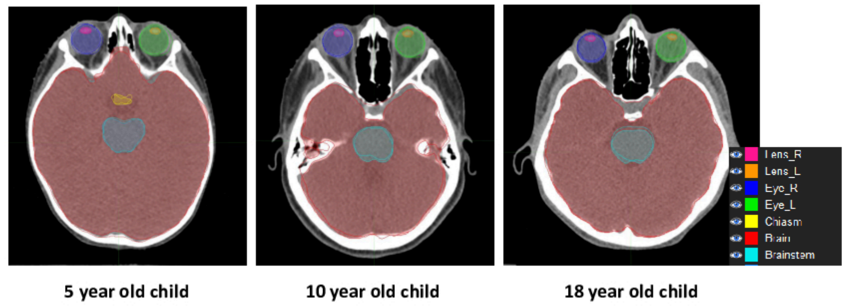


Figure 3: Visual representation of the performance of the auto-segmentation tool. The three images show axial slices of the **cranium** for one patient from each age group. The filled contours are drawn by a dosimetrist. The unfilled contours were generated by the auto-segmentation tool.

## 4. RESULTS (CONTINUED)

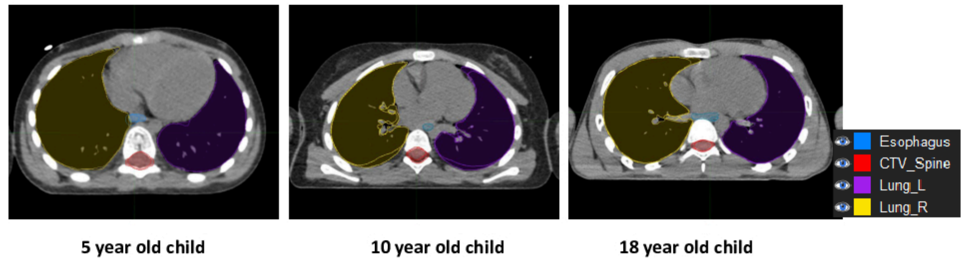


Figure 4: Visual representation of the performance of the auto-segmentation tool. The three images show axial slices of the **body** for one patient from each age group. The filled contours are drawn by a dosimetrist. The unfilled contours were generated by the auto-segmentation tool.

## CONCLUSIONS

- Three age-dependent atlas libraries were created for auto-segmenting structures in children receiving CSI, and the performance of the atlas was evaluated for 18 different structures. The mean DSC for all structures was 0.73 ± 0.23.
- The atlas segmentation tool performed well in terms of DSC for pediatric structures with volumes ≥ 550 cc.

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