Dosimetric and Geometric Evaluation of Five Commercial Contour Propagation Tools for Online Adaptive Radiotherapy

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INTRODUCTION

- In online adaptive radiotherapy, CBCT contours are required to determine whether intended dose delivery is sufficient or if a re-plan is indicated
- Manual contouring by oncologists is impractical [1], however automatic propagation of contours from planning CT to CBCT ideal but imperfect [2]
- However, rapid plan assessment is required to determine whether adaption is needed, however dosimetric implications of contour discrepancies unclear
- Limited information in literature on dose discrepancies [2]

AIM

To evaluate whether contours propagated by five commercial algorithms are geometrically similar to those manually drawn by a clinician, with the dosimetric impact of any differences evaluated. This is the first step to using automatic contouring directly in plan adaption.

METHOD

- Contours for the spinal cord, brainstem and parotids for five H&N patients were propagated to five weekly CBCTs via Pinnacle, ProSoma, RayStation, ADMIRE and Mirada (figure 1)
- Each CBCT independently contoured by an oncologist who reviewed the initial treatment plan
- The CBCTs were shader-corrected [3] to improve HU consistency for dose calculation
- The treatment plan was then recalculated in RayStation
- To assess contour geometrical similarity, the mean distance to agreement (mDTA) was calculated for all propagated contours using the clinician's contours as reference.
- To assess dosimetric impact of contour accuracy, relevant DVH parameters were extracted:
  - D1cc for the brainstem and spinal cord PRVs
  - Mean dose for parotids and larynx.
- These DVH parameters were compared against values derived from the clinician's contours.
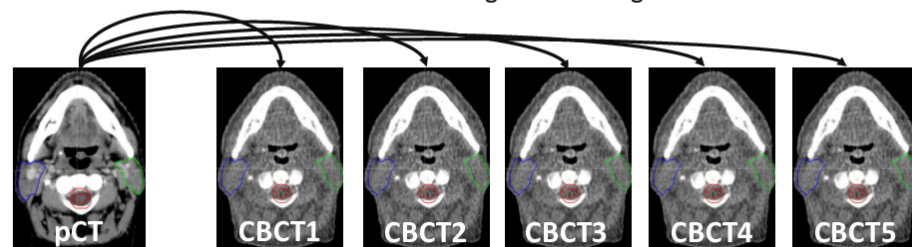- Dosimetric differences were tested using Wilcoxon signed-rank tests.

Figure 1. Contour propagations performed from pT to each of 5 CBCTs for the 5 applications.

RESULTS

- Good geometrical agreement was found for all propagated contours (mean mDTA 2.5±0.9mm),
- Larger differences for the brainstem (3.1±0.8mm) (table 1) due to Discrepancies in superior aspect (figure 2)
- Also parotids showed larger discrepancies in the anterior, inferior and superior aspects
- Spinal cord generally smaller on clinician contours
- Contouring difficult due to poor CBCT image quality
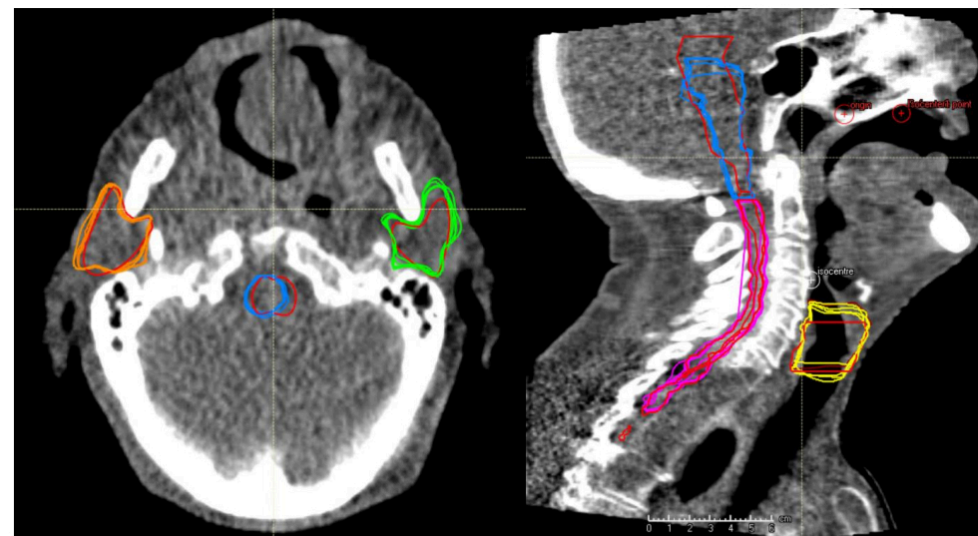- But mDTA (except brainstem) within accuracy of slice thickness (3mm), implying good propagation
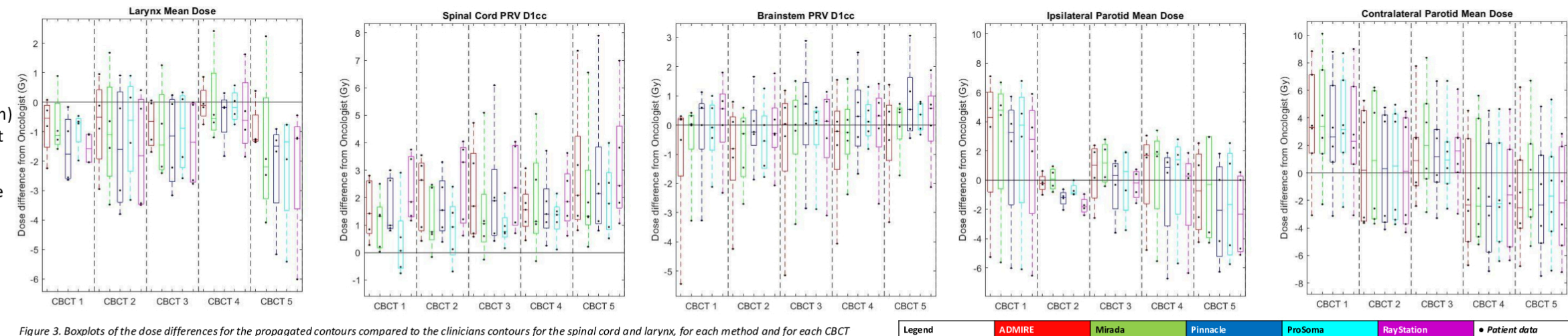

Figure 3. Boxplots of the dose differences for the propagated contours compared to the clinicians contours for the spinal cord and larynx, for each method and for each CBCT

Figure 2. Example of a single CBCT showing all propagated contours and the clinician contours (red).

- Dosimetric parameters were in general in agreement (figure 3 and table 2).
- For each CBCT and organ at risk (dividing the parotids into contra and ipsilateral parotids relative to the high dose PTV), the dose difference to the clinician drawn contours was generally small
- However, the dose difference was statistically significantly different for the spinal cord and larynx when grouped with all CBCTs and methods
- For volumes where steep dose gradients are present, such as the spinal cord and the larynx, any small variation in the contours may create a large dosimetric discrepancy.
- Conversely, areas with a shallow gradient (or no dose), large variations translated into small dosimetric discrepancies, e.g. D1cc variation for the brainstem was very low, as the inferior aspects of the contour agreed and generally low doses
- Emphasizes need to account for local dose environment when assessing contours for adaptive workflows to efficiently determine which contours require correction.

Organ at risk	Mean mDTA ± stdev (mm)
Brainstem	3.1 ± 0.8
Spinal cord	2.4 ± 1.0
Larynx	2.3 ± 1.1
Left parotid	2.4 ± 0.5
Right parotid	2.1 ± 0.4

Table 1. Mean mDTA for each organ for all CBCTs and patients for the five organs at risk selected for the study, stdev being the standard deviation.

Organ at risk	Mean dose difference ± stdev (p value) (Gy)
Brainstem	0.54 ± 1.47 (0.83)
Spinal cord	1.70 ± 1.95 (3.5×10⁻²¹)
Larynx	-1.08 ± 1.54 (7.9×10⁻¹⁰)
Ipsilateral parotid	-0.03 ± 2.72 (0.20)
Contralateral parotid	0.52 ± 4.27 (0.72)

Table 2. Dose differences and p values for each organ at risk. A positive number indicates that the propagated contour dose is higher than the clinician's, stdev being the standard deviation

CONCLUSIONS

- It has been shown that for most organs a good geometrical and dosimetric agreement is reached with any of the evaluated tools.
- Dosimetric differences, for the larynx and cord, could be explained by proximity to steep dose gradients.
- Geometric metrics do not correlate with dosimetric differences, emphasizing the need to fully understand the local dose environment when assessing propagated contours
- Further research is required to determine metrics, considering dose gradients, to assess when contour adjustments are required for adaptive radiotherapy

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