Evaluation of Volumetric Change and Dosimetric Discrepancy with Daily Cone-Beam CT for Patients with Head-and-Neck Cancer

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INTRODUCTION

In external beam radiotherapy of head-and-neck patients, the actual delivered dose could be quite different from the planned one due to the anatomic changes in both target and organs at risk. The purposes of this study are: (1) to evaluate the volumetric changes in the target and critical organs during IMRT treatment for patients with head-and-neck cancer; (2) to investigate the discrepancies between the planned doses and daily doses using cone-beam CTs; (3) to determine optimal replanning strategies.

METHODS AND MATERIALS

Patient data and initial treatment planning
- Eight adaptive head-and-neck patients
- Each patient had one planning CT (CT1), a mid-term CT (CT2), and daily CBCT scans
- 1.8 Gy * 40 fractions / 2 Gy * 35 fractions
- 6 MV photon beam and 9 beam IMRT

Manual and automatic contouring
- Manual contour: The target and critical structures were delineated by physicians for both CT1 and CT2. Contours were transferred from CT2 to CBCT2 (CBCT at the same day of CT2) after rigid registration as a reference, assuming patient anatomy did not change much for the same day.
- Automatic contour: CT2 (CBCT) were first rigidly registered with CT1 based on the bony structures. Contours of the target and critical organs were then deformed from CT1 to CT2 (CBCT) using MIM deformable registration algorithm.

Overlap analysis

Overlap Index   &   Dose similarity coefficient

$$OI = \frac{V_1 \bigcap V_2}{V_1} \qquad DSC = \frac{2(V_1 \bigcap V_2)}{V_1 + V_2}$$

Where V_1 and V_2 are volumes of ROI from the manual contours and deformed contours, respectively.

Dose mapping

After rigid imaging registration, the planning dose matrix was mapped to the CT2 (CBCT) images. The doses to the deformed structures were compared with the planned doses.
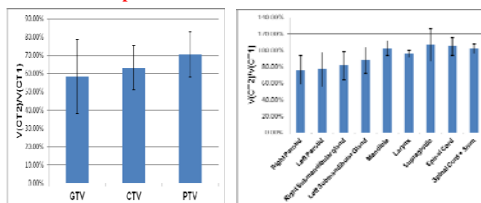
RESULTS

➤ **Volume comparison**

Figure 1: The relative volume variations between CT1 and CT2 for target (left) and critical structures (right).

➤ **Verification of MIM deformable algorithm: CT1→CT2(CBCT2)**
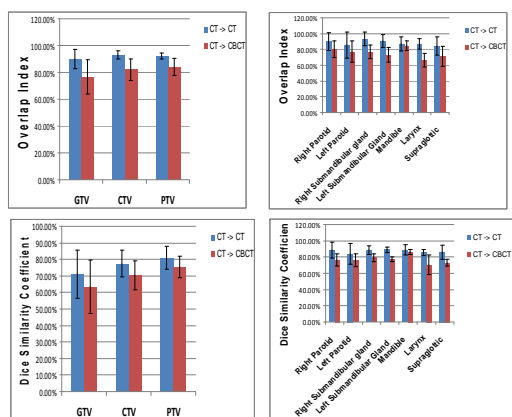
❑ Overlap analysis

Figure 2. Overlap index (top) and dice similarity coefficient (bottom) of CT1 and CT2 (CBCT2).
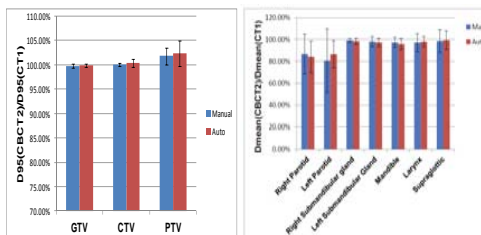
❑ Dosimetric evaluation

Figure 3. Dosimetric comparison of the target (left) and critical structures (right). Normalized to plan dose.

RESULTS

➤ **Daily volume and dose comparison**
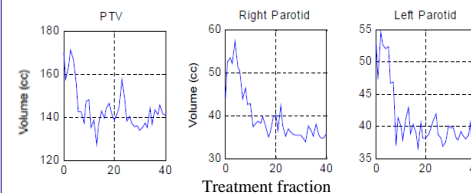
❑ Volumetric change

Figure 4. Volumetric changes across the treatment course for one patient with significant variations.
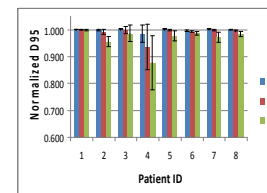
❑ Dose comparison for target

Figure 5: Normalized D95 for GTV, CTV and PTV.
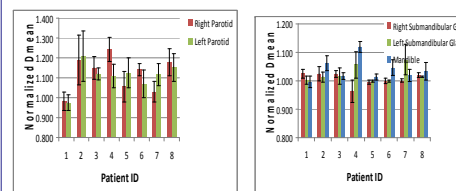
❑ Dose comparison for critical structures

Figure 6. Normalized mean dose for critical structures.

CONCLUSIONS

➤ Significant volume shrinkage in target and parotid gland were observed, but not for other critical organs.
➤ No significant changes in daily dose coverage of the tumor were observed despite of tumor shrinkage.
➤ The daily mean dose changes in the parotid glands were greater than other sensitive structures.
➤ With deformable contours from the planning CT, daily CBCT along with rigid dose transformation can provide quantitative dose guidance for replanning.