Off-Line Treatment Monitoring of Head and Neck Radiotherapy Using Daily Cone-Beam Computed Tomography: A Preliminary Study

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INTRODUCTION

To evaluate newly developed action level monitoring system to determine appropriate timing for adaptive plans, monitored and characterized exclusively for cohort of Head and Neck (H&N) patients.

AIM

Usually, decision making of Off-line Adaptive Planning (OAP) has been qualitatively made by physicians without quantitative values in most clinics. Our institution recently developed Action Level Dose and Anatomic Variation (ALDAV) for adaptive radiation therapy monitoring system (see Ref.1), which uses daily and/or weekly CBCT as an analysis tool to guide the radiation oncology team to aid in OAP.

METHOD

Daily or weekly CBCTs of which were used for patient setup have been collected daily basis for OAP. This system was built mainly by script function embedded in RayStation treatment planning system (TPS: RaySearch Laboratories AB, Sweden, V. 8A.1) and other miscellaneous computer script to automate the monitoring system. The action level was composed of two parameters, which are (1) Dosimetric parameters over ±5% from initial plan; D95, D90, D10 and D5 of target volume, and (2) HU differences using a Pearson Correlation Coefficient of lower than 0.75 (PCC) of target volume between very first CBCT and CBCTs followed in the course of treatment. This monitoring system sends e-mail to assigned physicist with those parameters in daily basis after automatic calculations. Total 33 H&N patients who have daily as well as weekly CBCTs were collected during the course of treatment as ALDAV monitoring scheme. Criteria to alert site specific assigned physicists are dosimetric parameters over ±5% from initial plan; D95, D90, D10 and D5 of PTV (or CTV), and HU differences of using Pearson Correlation Coefficient (PCC) lower than 0.75 between the very first CBCT and any CBCT of the day. Specifically, PCC is calculated as:

$$r_{ijk} = \frac{\sum_x \sum_y \sum_z [f(x+i,y+j,z+k)-\bar{f}][g(x,y,z)-\bar{g}]}{\sqrt{\sum_x \sum_y \sum_z [f(x,y,z)-\bar{f}]^2} \sqrt{\sum_x \sum_y \sum_z [g(x,y,z)-\bar{g}]^2}}$$

The PCC, r_{ijk}, represents the CT number similarity between two registered images at coordinate *x*, *y*, and *z*. Specifically, *i*, *j*, and *k* are relative positions shifted from *x*, *y*, and *z*. Mean values of CT number (or Hounsfield unit) represent $\bar{f}$ and $\bar{g}$. This comparison is performed between the first day of CBCT and following CBCTs.

METHOD (CONTINUED)

RESULTS

The primary results are depicted in Fig.1. As shown in the Fig. 1, 30 out of total 33 patients' PCC values were lower than 0.75 at any CBCT collected, and dosimetric parameters with greater tolerances was 11 out of 30. The PCC calculation is very sensitive parameter depending on set up error as well as imaging quality (kV, mAs, filter usage, etc.) at the day of CBCTs were acquired. On the other hand, dosimetric parameter was not as sensitive as PCC because the target volume was not deformed to each CBCT but only rigidly copied from the initial planning CT. However, any internal organ deformation and external skin shrinkage during the course of treatment will be reflected in dose calculation.

Fig. 2 shows 2 out of 4 patients both PCC and dosimetric parameters tolerances were exceeded more than two consecutive days. The upper graph shows that both PCC and dose parameters are off from the 5th CBCT from the 3rd week of treatment. While the lower plot shows that parameters started to deteriorate from the 7th week of treatment which was near the end of treatment. Fig.3. shows dosimetric difference detected by the system clearly shows discrepancy between plan CT and the CBCT.

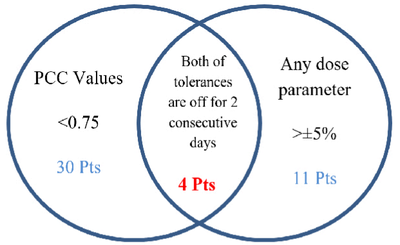

Fig. 1. Criteria that were used to alert OAP. 4 out of 30 patients were alerted to re-plan. 2 of them were alerted in the middle of treatment but others were alerted almost at the end of treatment. Only 3 out of 33 patients did not alert for both criteria during entire treatment.

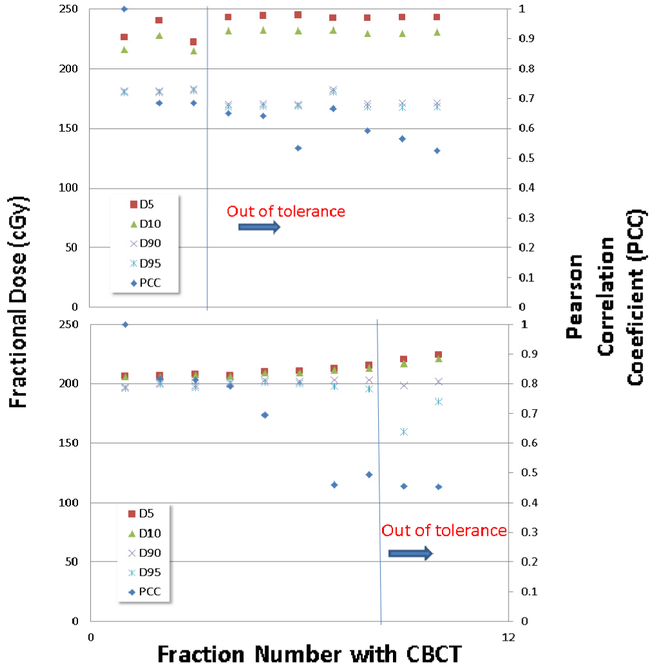

Fig. 2. Representative trends of two patients whose tolerances deviate from both criteria of target dose parameters. X axes are CBCT collected fractions. First three are daily and weekly thereafter.

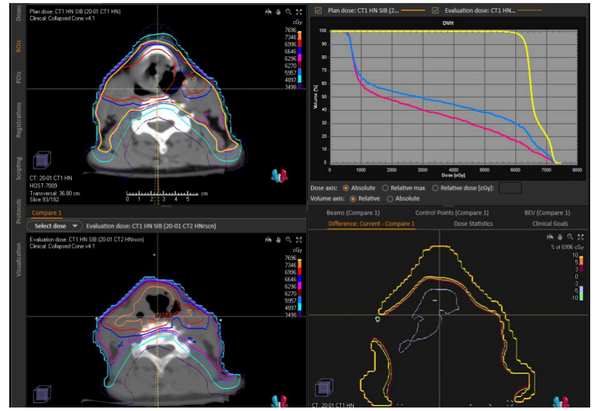

Fig. 3. One of patients detected by the monitoring system Right upper: Planned CT. Right loswer: CBCT)in the early stage of the treatments. OAP is obviously needed.

CONCLUSIONS

The automated monitoring system was successfully operated as a valuable tool to alert OAP timing. PCC variation was very sensitive due not only to misplacement setup but also CBCT image quality variation. The conjunction of dose parameters and PCC value changes complement to find optimal OAP as well as account for set up mistakes. Still team effort of investigation into cause of deviation of those parameters by a radiation oncologist, dosimetrist and physicist's review as well as prospect of clinical outcome is essential to make a decision on OAP.

REFERENCES

"Action Levels on Dose and Anatomic Variation for Adaptive Radiation Therapy Using Daily Offline Plan Evaluation: Preliminary Results" B. Zhang et al. Practical Radiation Oncology (2019) 9, pp. 49-54

CONTACT INFORMATION

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