Assessing the target shift and its effect on dose distribution using deformable image registration method for head and neck patients undergoing IMRT

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Background and Objective

Intensity modulated radiation therapy (IMRT) generates highly conformal dose and thus accuracy of target position across treatment fractions is important[1].

Deformable image registration (DIR), also known as non-rigid image registration is a process of defining spatial correspondence between two considered image sets[2].

This study was aimed to assess the target shift in relation to other structures during IMRT treatment and the effect on the dose distributions using DIR method.

Methods

This is a retrospective study. Head and neck IMRT patients were selected in the ARIA oncology information system v15.5 (Varian Medical Systems, Palo Alto, California).

The Eclipse treatment planning system v15.5 (TPS, Varian Medical Systems, Palo Alto, California) was used to generate the deformed CT images (dCT), by performing the DIR for both planning CT (pCT) and cone beam computed tomography (CBCT) images.

The centre of mass of the primary tumour PTV 70 and dose distributions for organ-at risk (OAR) for all data set was computed.

DATA COLLECTION

Eligible IMRT patients were selected. Patient images and treatment plan were retrieved from the TPS for further data processing and analysis.

IMAGE PROCESSING

Deformable Image Registration

Weekly CBCT + Planning CT (pCT) → Deformed CT (dCT) → Magnitude of target shift (x,y,z)

EXECUTE

Recalculated dCT with known shift coordinates → Compared dose deviation of OARs based on dose volume histogram

Results and Discussion

During the pilot study, eight patients were selected.

A series of dCT were successfully generated for each patient, enabling further quantification work to be carried out.

Figure 1 shows the example of the dCT generated from pCT and CBCT of patient with nasopharyngeal cancer (NPC).

The preliminary result showed that the average target shift for the PTV was 0.05 ± 0.04 cm (ranged between 0.00 and 0.24 cm).

For dosimetry analysis, no significant changes on OARs (brainstem and spinal cord) were observed and all were below tolerance limits as shown in Figure 2.

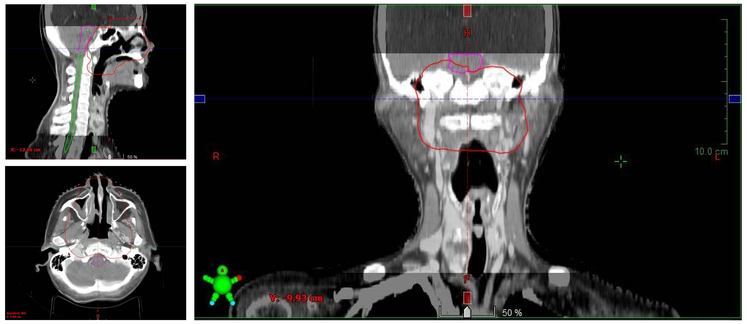

Fig 1. The deformed CT images (axial, sagittal and coronal view) around the PTV (volume of interest from brainstem to cervical level).

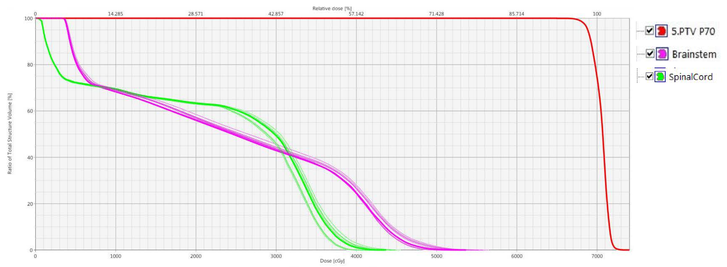

Fig 2. Dose volume histogram for PTV and dose uncertainty for pre-defined organ-at-risks (OARs) calculated by the treatment planning system.

Table 1. Summaries of preliminary data for average target shift, approved and average recalculated dose for organs-at-risk over 7 weeks of radiotherapy treatment.

Patient	Average target shift (SD), cm	Spinal cord (Dmax), Gy		Brainstem (Dmax), Gy	
		Approved	Recalculated (SD)	Approved	Recalculated (SD)
1	0.09 (0.05)	16.89	16.06 (0.62)	23.68	23.22 ± 1.05
2	0.09 (0.07)	45.28	46.48 (1.65)	60.33	60.75 ± 1.60
3	0.02 (0.02)	44.24	45.58 (0.39)	53.26	54.06 ± 0.69
4	0.06 (0.03)	44.38	43.93 (0.17)	60.86	60.10 ± 1.36
5	0.05 (0.03)	45.67	47.19 (0.60)	59.27	60.20 ± 0.79
6	0.05 (0.04)	42.37	43.15 (0.48)	64.58	64.89 ± 0.82
7	0.04 (0.04)	44.31	43.58 (0.16)	50.95	50.25 ± 0.50
8	0.04 (0.03)	42.34	43.53 (1.52)	53.5	53.86 ± 2.20

Conclusions

- This study demonstrates a quantitative method to assess target shift over fractionated treatment and to evaluate its effect on the dose distribution of OARs for head and neck patients undergoing IMRT.
- The generated data can be served as base line data and would be useful in future in particular for adaptive radiotherapy.

References

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[2] Seungjong O, Siyong K. Deformable image registration in radiation therapy. Radiat Oncol J 2017;35(2):101-111.