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MRI-based Synthetic CT images for IMPT Treatment Planning of Nasopharyngeal Carcinoma Patients

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reduced range uncertainty was evaluated for OARs and ring structures of various thickness (from 1mm to 20mm) surrounding the CTV. Comparisons were made by evaluating mean and max dose to OARs and ring structures.

Results

The results show that reducing the range uncertainty in the treatment plan gives a slight reduction in nominal dose to the surrounding tissue. Mean dose to brain outside CTV (Brain-CTV) is on average reduced by 3.4%(std=0.2%) over the ten patients when reducing range uncertainty from 3.5% to 2%. Dose to the ring structure of 10mm surrounding the CTV was reduced by 2% on average. In the worst-case scenarios for Brainstem and Chiasm, reducing the range from 3.5% to 2.0% results in a reduction in max dose by 4.1% (0.7Gy) and 4.7% (1.5Gy) respectively. Table 1 contains the average dose differences for the evaluated OARs.

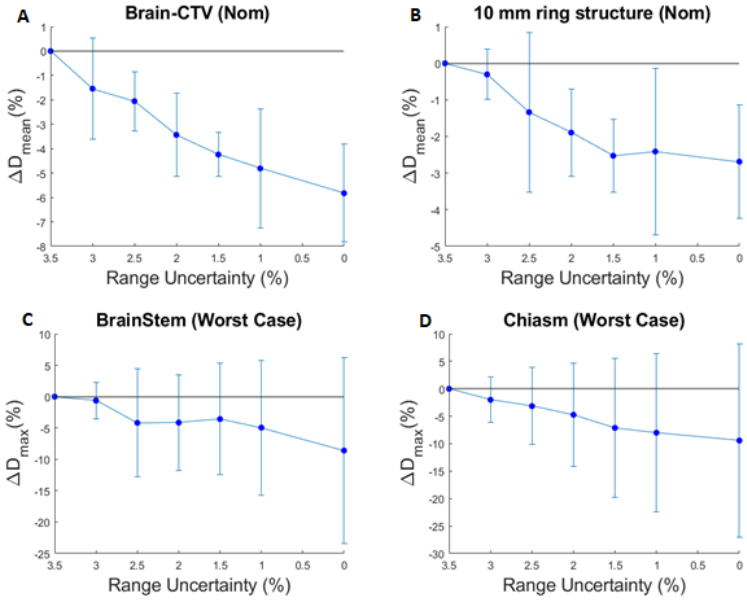

Figure 1: Relative dose difference compared to the reference plan (3.5% range uncertainty) averaged over the patients. The error bars show the standard deviation over the patients. A and B show the relative dose difference in the nominal scenario (Nom) for the Brain-CTV and the 10 mm ring structure around the CTV. C and D show the relative dose difference in the worst-case scenario for the robust evaluation.

Table 1: Relative dose difference compared to the reference plan (3.5% range uncertainty) for the nominal and worst-case scenario in relevant OARs.

Range uncertainty (%)	Relative dose difference compared to 3.5% plan (%)								
	Brain-CTV (Dmean)	Brainstem (Dmax)		Chiasm (Dmax)		OpticNerve Left (Dmax)		OpticNerve Right (Dmax)	
	Nom	Nom	Worst Case	Nom	Worst Case	Nom	Worst Case	Nom	Worst Case
3.0	-1.5	-1.3	-0.6	-0.8	-2.0	-0.4	-0.4	-1.7	-2.8
2.5	-2.1	-2.7	-4.2	-2.0	-3.2	-1.7	-1.3	-1.7	-4.2
2.0	-3.4	-2.2	-4.1	-1.5	-4.7	-1.9	-2.4	-1.8	-5.5
1.5	-4.2	-0.9	-3.6	-1.6	-7.1	-2.3	-3.2	-0.7	-6.2
1.0	-4.8	-2.1	-5.0	-0.6	-8.0	-2.7	-4.5	1.2	-11.9
0.0	-5.8	-4.4	-8.6	0.7	-9.4	-4.5	-8.2	-1.1	-11.2

Conclusion

Reducing the range uncertainty leads to meaningful reductions in dose to OARs. Whether the reduction is clinically relevant or not needs to be seen in a context; if the dose to OARs is close to the dose constraints maximum, the reductions shown in this study are very relevant. To obtain a relevant dose reduction of 2% in the mean dose to the brain outside CTV, new modalities such as DECT needs to ensure that the range uncertainty can be reduced down to 2-2.5%.

PO-1503 MRI-based Synthetic CT images for IMPT Treatment Planning of Nasopharyngeal Carcinoma Patients

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Purpose or Objective

To investigate the feasibility of using an MRI-based synthetic CT image (SCT) generated via a generative adversarial network (GAN) for intensity-modulated proton therapy (IMPT) treatment planning of nasopharyngeal carcinoma (NPC) patients.

Materials and Methods

T1-weighted MR images and paired CT (PCT) images were obtained from 158 NPC patients with radiotherapy immobilization. Deformable image registration was performed between each MR and PCT image for each patient to create an MR-CT pair. Thirteen pairs were randomly chosen as independent test sets and the remaining 145 pairs (10 for validation and 135 for training) were used to build a conditional GAN model, including a residual-Unet as a generator and a 6-layer convolution neural network as a discriminator. For each test patient, SCT was generated using the generator with the MR image as input. A 4-beam IMPT plan was created and optimized on the corresponding PCT, and the dose matrix was recalculated on the SCT. The dosimetric accuracy was evaluated by using the clinically relevant dose-volume histogram (DVH) parameters and 3D gamma index analysis.

Results

The mean absolute error between the PCT and SCT images were (89.64±20.54)HU within the body. **Figure 1** shows the MR, PCT, SCT, and HU errors for a patient with an average performance of CT number accuracy. The DVH parameters discrepancy between dose matrices calculated on PCT and SCT were (0.13±0.13)%, (0.4±0.44)%, (0.81±0.78)%, (1.25±1.26)%, (1.24±0.78)%, and (1.35±1.1)% for CTV1-D95, CTV2-D95 (involved nodes), Left-parotid mean dose, right-parotid mean dose, brain stem D1, and spinal cord D1, respectively. **Figure 2** shows the dose matrices calculated on the PCT and SCT as well as the DVH of critical structures and targets for a patient with an average performance of dosimetric accuracy. The 3%/3mm (10% threshold) gamma passing rate was (97.26±2.35)% within the head and neck region for the 13 test patients.

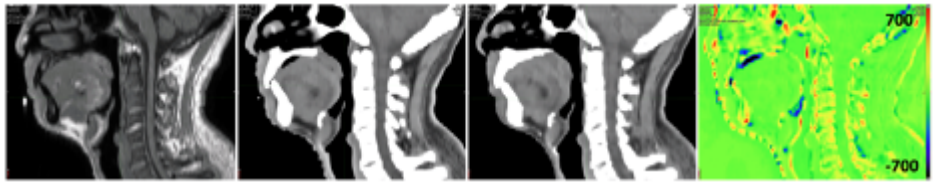

Figure 1 (Left to right) MR, paired CT (PCT) and synthetic CT (SCT) as well as the HU error for a patient with an average performance of CT number accuracy (mean absolute error = 86.66 HU).

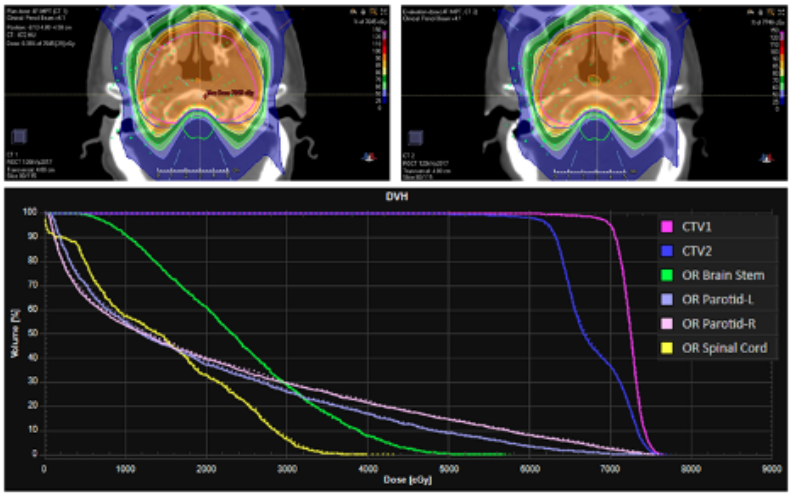

Figure 2 Dose matrices calculated on paired CT (PCT) (top left) and synthetic CT (SCT) (top right) as well as the dose-volume histogram (bottom) (solid line: PCT and dashed line: SCT) for a patient with average performance of dosimetry accuracy (3%/3mm gamma passing rate = 97.7%)

Conclusion

Overall, the SCT generated from MRI using GAN model achieved clinical acceptable dosimetric accuracy of IMPT planning for NPC patients. However, further study is needed to validate the SCT algorithm on a larger patient cohort before clinical implementations.

PO-1504 Comparison of single and dual-energy CT based proton treatment planning for neuro patients

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Purpose or Objective

To fully exploit the benefits of proton therapy, an accurate stopping power ratio (SPR) prediction is necessary. In this study, we evaluated the dose differences between robustly optimized proton plans based on single-energy CT (SECT) and dual-energy CT (DECT) for neuro-oncological patients.