# Clinical evaluation of deep learning based synthetic CTs from CBCTs for head-and-neck proton therapy

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## Introduction

- Anatomical variations are frequently seen for head-and-neck cancer patients during the proton therapy treatment course.
- The impact of these anatomical changes with respect to the delivered dose needs to be monitored. However, this cannot consistently be done directly on in-room cone-beam CT (CBCT) due to low image quality.
- A new deep learning based CBCT correction method, known as the Cycle-consistent Contrastive Unpaired Translation (CycleCUT), has recently been proposed.

## Aim

The aim of this study was to evaluate synthetic CTs (sCTs) generated from CBCT using a 3D CycleCUT network, in terms of proton dose calculation accuracy.

## Methods

- A total of 74 (20) head-and-neck cancer patients were used to train (test) the network.
- For the test patients, a CBCT and CT (rCT) pair was selected (anatomically similar).
- The rCT was deformably registered to the corresponding CBCT to create a ground-truth rCT (gt-rCT) to compare the sCT to.
- The structure set was deformably propagated from the planning CT to the sCT and gt-rCT, and the clinical proton plan was re-calculated on the gt-rCT and sCT.
- The proton dose distributions on the sCT and gt-rCT were compared in terms of dose-volume-histogram (DVH) parameters for target coverage and organ-at-risk (OAR) dose, as well as 3D gamma analysis (global evaluation; 1%/2mm, 2%/2mm, 3%/2mm and 3%/3mm).

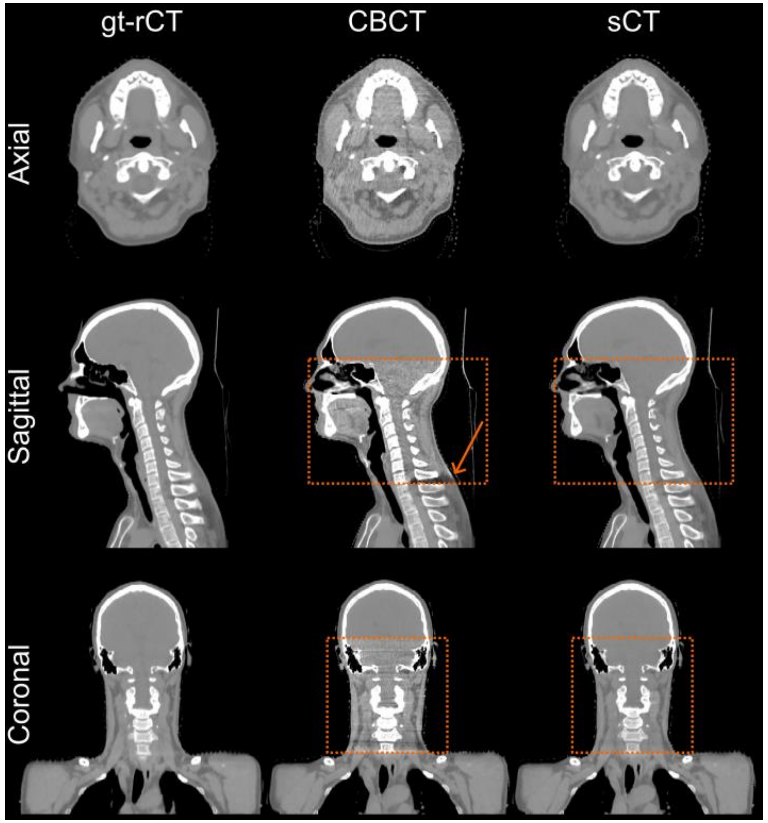


**Figure 1: Axial, sagittal, and coronal slices of the ground-truth repeat CT (gt-rCT), the cone-beam CT (CBCT), and the synthetic CT (sCT) for a representative test patient. The CBCT field-of-view is indicted by a dashed orange box. The orange arrow at the sagittal CBCT slice indicates a CBCT artefact, which was corrected on the sCT.**

## Results

- The sCTs were found to accurately preserve the CBCT anatomy, while improving the image quality (Figure 1).
- Proton dose difference seen for the sCTs were small (Figure 2).
- The largest median DVH difference for the target was found for D99% of the intermediate-risk target (CTV2; 0.4 percent point), while the largest OAR difference was Dmean of the combined submandibular glands (0.8 Gy), indicated by bold labels in Figure 2.
- Gamma passing rates were above 97% for all evaluated criteria.

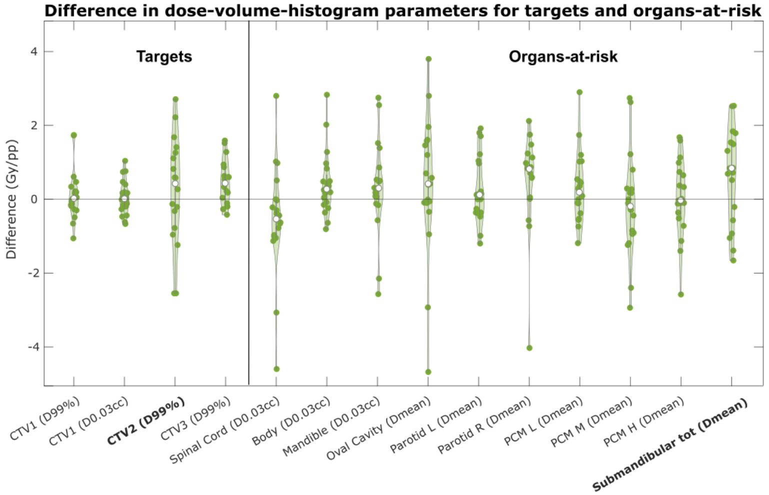


**Figure 2: Violin plots (overlaid by the datapoints) over the differences for dose-volume-histogram parameters between the dose distribution calculated on the ground-truth repeat CT (gt-rCT) and synthetic CT (sCT), for the targets (left) and organs-at-risk (right).**

## Conclusion

The evaluated deep learning network generated high-quality sCT images with proton dose distributions comparable to those of conventional fan-beam CT.