MEDICAL UNIVERSITY OF VIENNA

Evaluation of a novel CBCT conversion method

Wolfgang Lechner[1], Sarah Haupt[1], David Kanalas[2], Lukas Zimmermann[2], Dietmar Georg[1]

[1]Department of Radiation Oncology, Medical University of Vienna, Vienna, Austria
[2]Faculty of Engineering, University of Applied Sciences, Wiener Neustadt, Austria

Purpose

To evaluate a novel implementation of a CBCT conversion algorithm for dose calculation implemented in a commercial treatment planning system.

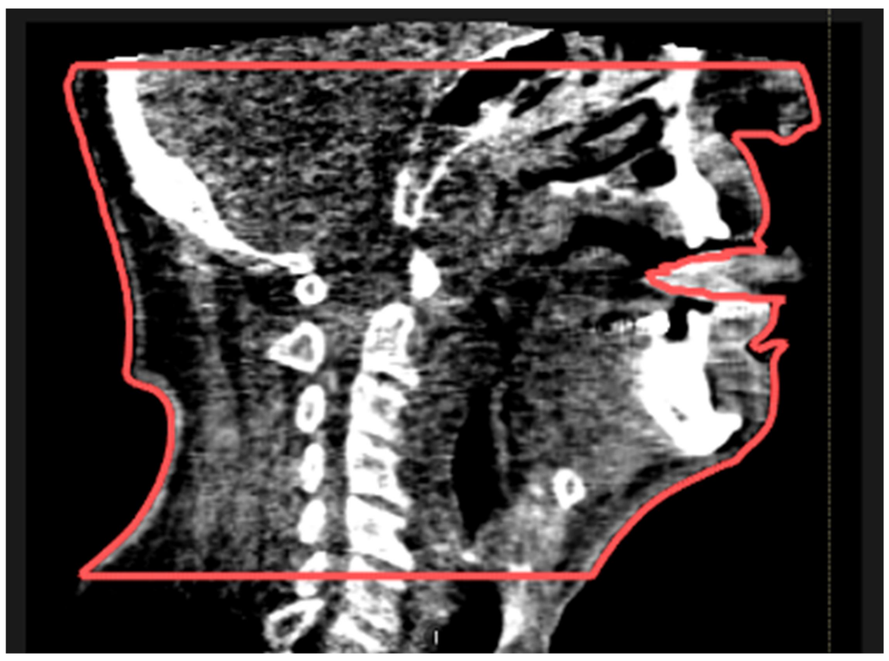

Figure 1: Evaluated region of the image data sets. The truncated regions were avoided.

Results

Figure 3 shows a box-plot of the gamma pass rates (GPRs). For both Figures, on the left the deformed CT was used as ground truth, while on the right it was the planning CT. Furthermore, the Figures are grouped by conversion method and GRP threshold for the head and neck and gynecology cases, respectively. On average, both conversion algorithms show GPRs higher than 90% and 80% for H&N and Gyn, respectively. The GPRs for the $CBCT_b$ method were systematically lower compared to the $CBCT_c$ method. These differences were statistically significant for the Gyn cases for all thresholds and statistically significant for the 10%, 30% and 50% threshold for the H&N cases. The main differences between the dose calculated on the CBCTs and the pCT or dCT were found in regions where weight loss occurs frequently or at air/tissue interfaces, which are also subject to anatomical variations.

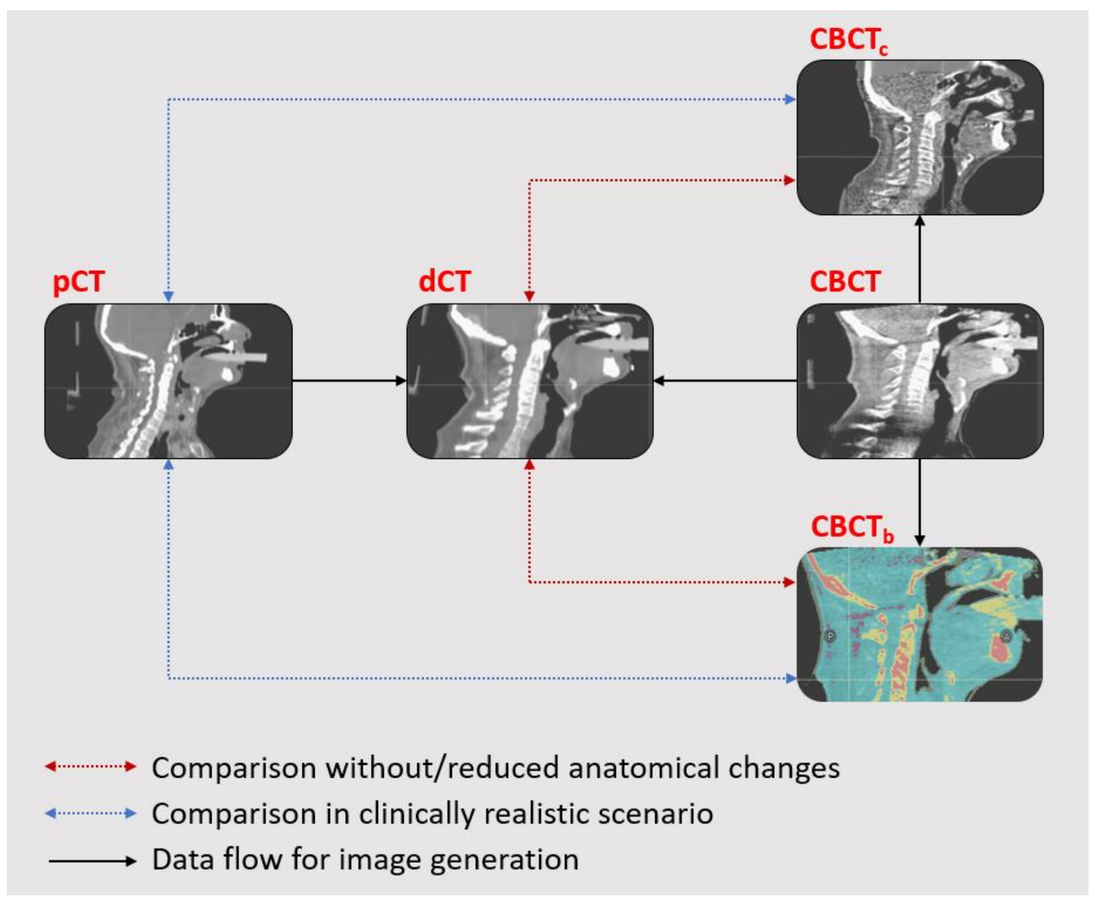

Figure 2: Data generation and analysis workflow.

Materials and Methods

Cone beam CTs (CBCTs) acquired for ten head and neck (H&N) and ten gynecology (Gyn) patients were collected and converted using a new algorithm for dose calculation implemented in a development version of RayStation (v. 10B-DTK, RaySearch, Stockholm, Sweden) resulting in corrected CBCTs ($CBCT_c$). A bulk density overriding technique implemented in the same version of RayStation was used for comparison ($CBCT_b$). The planning-CT (pCT) was elastically registered to the CBCT to create a deformed CT (dCT) with less anatomical differences compared to the CBCT.
Treatment plans, which were optimized on pCT, were recalculated on the $CBCT_c$ the $CBCT_b$ and the dCT. The resulting dose distributions were analyzed using local gamma analysis with 1% dose difference and 1 mm distance to agreement implemented in the MICE toolkit (NONPIMedical AB Sweden, Umeå). Both, the pCT and a dCT was used as ground truth. Four different dose thresholds were used for the analysis: 10%, 30%, 50% and 90%. The evaluation was restricted to the non-truncated volume of the CBCT (see Fig. 1). A paired Wilcoxon-test was applied to test the differences in GPRs between the $CBCT_c$ and $CBCT_b$ method. A p-value smaller than 0.05 considered statistically significant. The workflow is shown in Fig. 2.

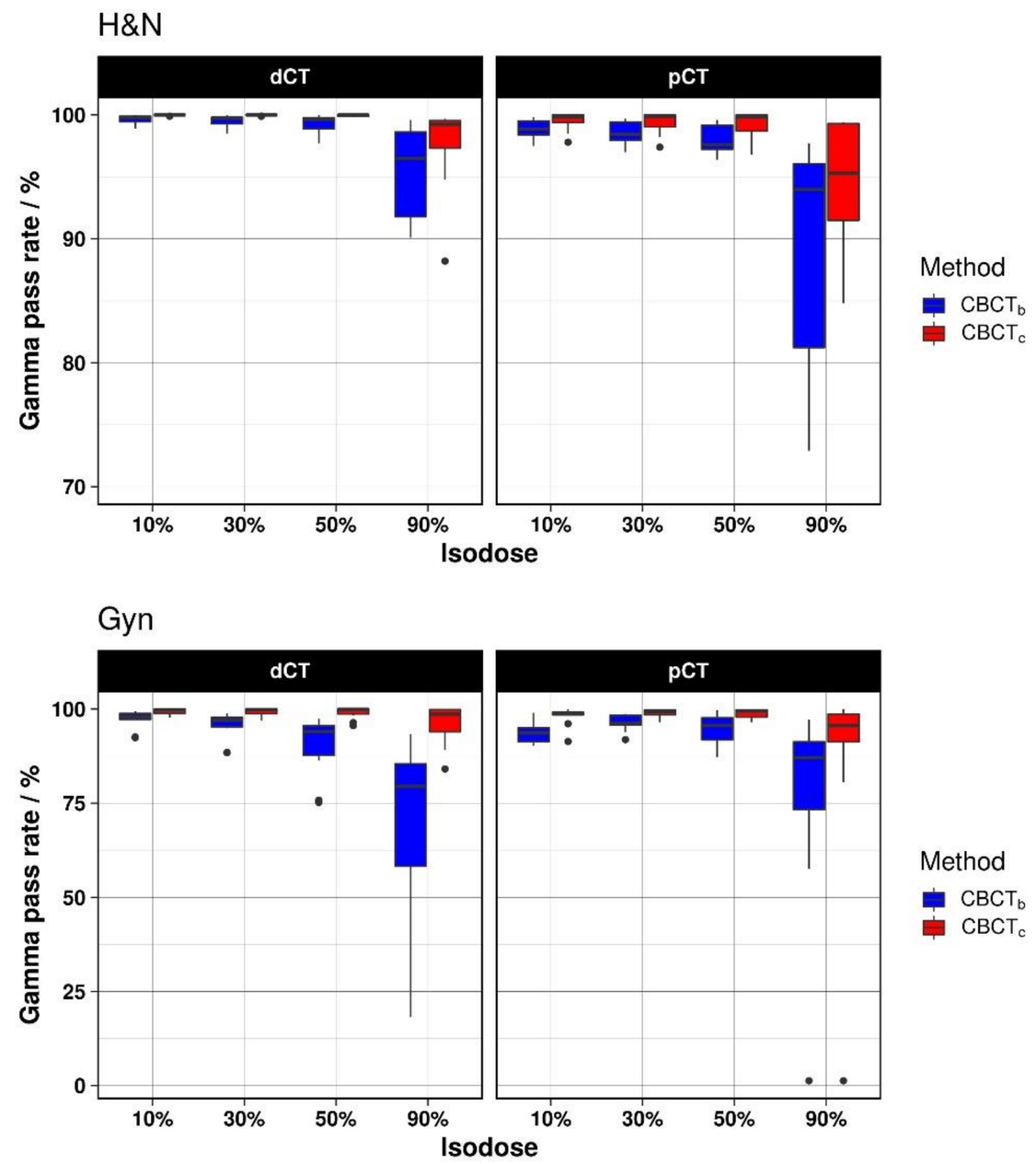

Figure 3: Box-plots of GPRs for H&N (top) and Gyn (bottom).

Conclusion

The dose distribution calculated using the new $CBCT_c$ method showed excellent agreement with the dose calculated using pCT as well as the dCT and was found to be superior to the $CBCT_b$ method. The main reasons for deviations of the calculated dose distribution were caused by anatomical variations between the dCT and the corrected CBCT. Based on these findings, the new method can be introduced into clinical practice.