Dosimetric comparison of kVCT- and synthetic CT-based adaptive workflows on a tomotherapy system - Comparaison dosimétrique de workflows adaptatifs en tomothérapie basés sur kVCT et CT synthétique

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Résumé

Introduction: The 3D kVCT imaging system integrated into tomotherapy machines, primarily used for daily patient positioning, has the potential to support dose calculation and adaptive replanning. Synthetic-CT (sCT) images generated by the treatment planning system represent an alternative approach for adaptive workflows. This study aims to compare the dosimetric accuracy of treatment plans calculated on sCT and kVCT images, firstly on a phantom and secondly on patients with different treated localizations.
Materials and Methods: Two adaptive workflows were evaluated in this study. The first approach consisted of direct dose calculation on the daily kVCT image acquired at the treatment machine. In this case, physical densities were assigned using HU-to-density calibration curves specific to the imaging protocol1. For phantom data, structures were transferred from the planning CT (pCT) to the kVCT using rigid registration, whereas for patient data, deformable image registration was employed. The second workflow relied on dose calculation on a sCT generated within RayStation v2025 using the *Corrected CBCT* algorithm available in the automated replanning module. The sCT was generated through deformable registration between the kVCT and the pCT to reproduce the daily anatomy, while density information was retrieved from the pCT. Structures were propagated via the same deformable mapping, and the HU-to-density calibration curve associated with the pCT was used for dose calculation. Test 1 consisted of performing both workflows to the Gammex phantom (Sun Nuclear). Four tomohelical treatment plans were generated, each with a different density insert as PTV. Test 2 extended the analysis to three patient cases (head-and-neck, pelvis, thorax), and for which an adapted requiring an adaptation of their initial treatment plans. For those patients, a pCT and a kVCT were acquired on the same day and in a short period of time. For both tests, the mean dose to the target (PTV for phantom, CTV for patients)

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was compared between kVCT-based and sCT-based calculations, considering the dose computed on the pCT as reference. To further assess uncertainties related to sCT generation, the pCT was used both as the reference image and as the daily image (Test 3). This test was repeated five times on patient datasets to evaluate the intrinsic accuracy and repeatability of the algorithm.

Results: Test 1 showed dose deviations ranging from –1.2% to –0.4% for kVCT-based calculations, whereas deviations for sCT were smaller, ranging from –0.2% to 0.1%. The plan with the central solid water insert as PTV exhibited the largest deviation, likely due to a larger density range on the beam path. Test 2 demonstrated overall low dose deviations for all patient cases, with slightly improved accuracy observed for sCT-based calculations (Fig.1). Test 3 yielded a standard deviation of 0.01% in the mean dose to the CTV, indicating high repeatability of the sCT generation and dose calculation process.

Conclusion: This preliminary study may suggest that kVCT- and sCT-based adaptive workflows provide comparable dosimetric accuracy for dose recalculation in tomotherapy. Future work will extend this evaluation to a larger patient cohort in order to confirm the robustness of these results across treatment sites. Particular attention will be given to the impact of deformable image registration on each workflow, as it may influence both structure propagation and dose calculation accuracy in adaptive radiotherapy.
(1)Capacci et al. *Characterization of HU-to-density calibration for kVCT imaging in Adaptive Radiotherapy workflows.* Abstract accepted as PosterHighlight for Estro 2026.

Mots-Clés: Adaptive radiotherapy, tomohelical treatments, synthetic CT, kVCT