

Cone Beam CT as a clinical QA tool for prostate MRI-only workflows

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INTRODUCTION AND OBJECTIVES

Magnetic resonance imaging (MRI) only radiotherapy is performed without computed tomography (CT) and instead, a synthetic CT (sCT) is used for treatment planning. With the introduction of new procedures for treatment planning, development of quality assurance (QA) tools must be considered.

The aim of this study was to develop and validate a clinically feasible QA procedure for sCT using the cone beam CT (CBCT), in an MRI-only workflow for prostate cancer patients.

METHODS

Three criteria were addressed;

1. Stability in Hounsfield Units (HUs),
2. Deviations in HUs between the CT and CBCT and
3. Validation of the sCT QA procedure.

For the initial two criteria, phantom measurements were performed. For the third criterion, sCT, CT and CBCT for ten patients were used. Treatment plans were created based on the sCT (MriPlanner™, Spectronic Medical AB, Sweden). Based on a rigid image registration, the sCT-treatment plan was copied and recalculated on the CT and CBCT. Dose-volume histogram metrics were used to evaluate dosimetric differences between the sCT plan and the recalculated CT and CBCT plans. Well defined errors were artificially introduced in the sCT for one patient (Figure 1) to evaluate efficacy of the QA procedure.

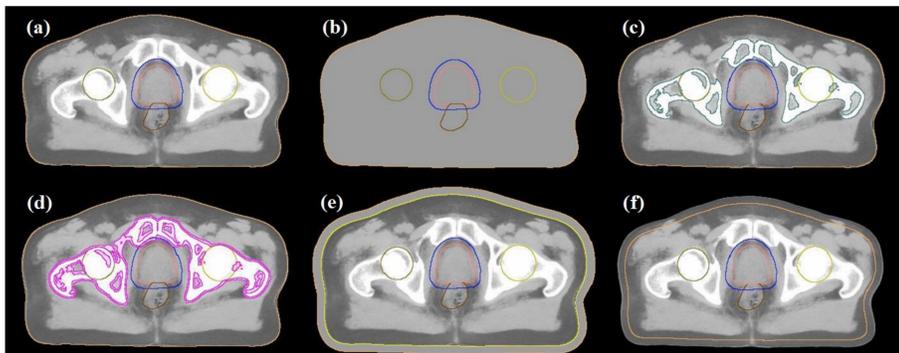


Figure 1. Illustration of the original sCT and the sCTs with errors introduced. (a) original sCT, (b) all tissue assigned to water, (c) bone structure assigned to cortical bone, (d) enlarged bone structure with 2 mm cortical bone, (e) enlarged patient body contour with +10 mm water and (f) decreased patient body contour with -10 mm. The delineations in the images are PTV (blue), CTV (pink), femoral heads (yellow) and rectum (brown).

RESULTS

The kV-CBCT system was stable in HU over time (SD <40 HU). Difference in HUs between CT and CBCT was very small (<60 HU). The mean differences between sCT-CT and sCT-CBCT dose distributions were below or equal to 1.0%. The highest mean dose difference for the CT and CBCT dose distribution was 0.6%. No statistically significant difference was found between total mean dose deviations from recalculated CT and CBCT plans, except for right femoral head. The proposed QA method was found very helpful in identifying the artificially introduced errors.

CONCLUSION

The results in this study show that CBCT can be used as a clinically feasible QA-tool for MRI-only radiotherapy of prostate cancer patients. The proposed method could easily be integrated in any modern image guided radiotherapy workflow without extensive work.

Prescription	CTCB - sCT SD	CBCT - sCT SD	CI
PTV D _{mean}	-0.5	0.5	[-0.2 0.8]
PTV D _{98%}	-0.6	0.5	[-0.4 0.6]
PTV D _{95%}	-0.6	0.5	[-0.4 0.6]
CTV min	-0.6	0.7	[-0.3 1.0]
Rectum D _{30%}	0.5	1.1	[-0.1 1.5]
Rectum D _{15%}	-0.4	0.6	[-0.3 1.0]
Rectum D _{10%}	-0.8	0.8	[-0.6 0.8]
Bladder D _{mean}	-0.1	0.6	[-0.2 0.7]
Left femoral head D _{2%}	0.2	1.1	[-0.1 1.4]
Right femoral head D _{2%}	-0.2	0.2	[0.0 0.6]
BODY D _{0.1%}	-0.8	0.5	[-0.6 0.4]

Table 1. Total mean dose deviation in DVH metrics between sCT and CT data sets and between sCT and CBCT data sets for 10 patients. The deviations are expressed in percentage of prescribed dose. Confidence interval for each DVH metric resulting from the independent two-sample t-test are presented in the most right column.

Error introduced	sCT- sCT with error	CBCT - sCT with error
sCT Water	-0.9	-0.8
sCT Cortical Bone	-3.4	-3.4
sCT Enlarged Bone	1.8	1.9
sCT Enlarged Body	3.6	3.7
sCT Decreased Body	-3.2	-3.1

Table 2. Difference in PTV D_{mean} between the plan calculated on sCT with error and the recalculated sCT and CBCT plans, evaluated for one patient. The comparisons are presented in percentage of the prescribed dose.

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