ABSTRACT SUBMISSION FORM

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6th MR in RT Symposium 2018

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PRESENTATION TITLE

Development of a method to assess on-set treatment 3D positional verification for MR-only pathways.

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ABSTRACT

development of a method to assess on-set treatment 3D positional verification for MR-only pathways.

Purpose:
Synthetic-CT (sCT) generation enables MR-only radiotherapy planning, however on-set 3D positional verification currently relies on CBCT-CT registration. As CBCT-MR registration is typically clinically unavailable CBCT-sCT registration may be applicable, but requires validation. Due to positional variation and deformation between planning CT (pCT), MR, and CBCT no ground-truth based validation of registration is possible.

We have established a generalizable, algorithm-independent, method of assessing additional errors induced by substitution of sCT for pCT in on-set positional verification using CBCT. Validated on a group of rectal cancer patients.

Materials & Methods:
Seven male rectal cancer patients each with pCT, sCT, and two CBCTs. pCT (Siemens Somatom Sensation, 0.97x0.97x2mm resolution) and T2-weighted MR (Siemens Aera 1.5T, 1x1x1mm resolution) were acquired in the radiotherapy treatment position. CBCTs (Elekta XVI, 1x1x1mm resolution) were acquired pre- and post-first treatment fraction. sCTs were generated by MRIplanner (Spectronic Medical AB, Helsingborg, Sweden) using a prostate model, the closest available proxy for rectal anatomy.

Each CBCT was rigidly registered to pCT, sCT and the other CBCT (Mirada RTx, 6 DoF - translation and rotation, mutual information). Registrations (fig 1a) were performed once globally (bony match),

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and once with a clinically relevant soft tissue clipbox. Affine transformation matrices were multiplied such that two equivalent registration pathways (i.e Paths 1 and 2 (fig 1b)) were generated for each dataset. Assuming perfect registration, differences between paths (I.e. a - (b + c)) represents non-rigid deformation between CBCTs, unaccounted for by rigid registration.

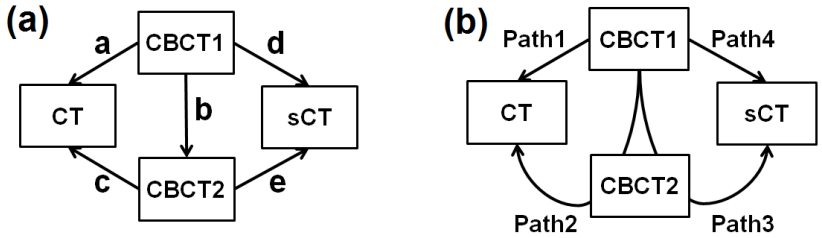

Figure 1: (a) Individual registrations performed between CBCTs, CT, and sCT. (b) Registration pathways utilised for substitution analysis

In principle sCT substitution should not introduce additional errors, as sCT or pCT specific deformations are present in both paths. Therefore observed differences between analysis with pCT (path1 - path2) and sCT (path3 - path4) indicates additional registration error, resulting from sCT use. All individual registrations were also assessed visually for clinical acceptability.

Results:

sCT substitution did not cause clinically significant (>2mm/1°) degradation of registration quality, using global registration (fig 2 - red). However, for several cases, clipbox based soft-tissue registration caused clinically significant increases in registration errors (fig 2 - black).

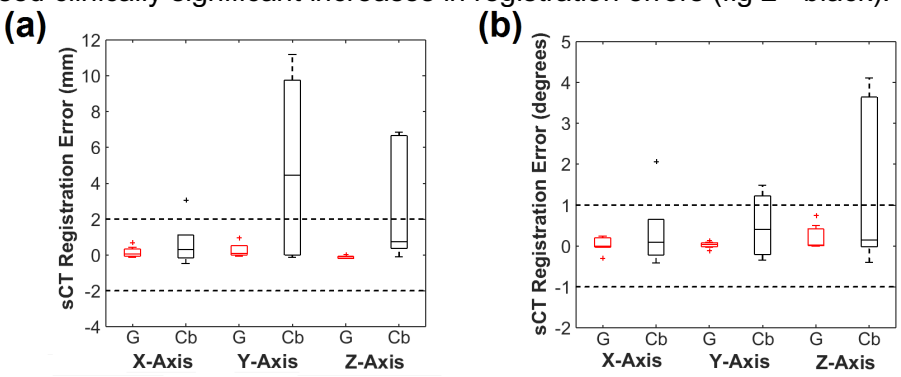

Figure 2: Box and whisker plot (median, interquartile range, and extreme values) for induced registration errors through sCT substitution. (**a**) translations, (**b**) rotations. G = global, Cb = clipbox.

Global sCT registrations were therefore deemed as accurate as pCT. One pCT clipbox registration failed to achieve clinical acceptability, attributed to poor CBCT quality, and was excluded. 50% of the remaining clipbox registrations showed additional errors >2 mm and/or 1° for sCT, indicating potential difficulties of soft tissue CBCT-sCT registration.

Conclusions:

We observed clinically significant degradation of registration quality for CBCT-sCT soft-tissue matching. Reliability of sCT global matching indicates MR distortion is insignificant, and failure of soft tissue based registrations implicates greyscale compression or inaccuracy within the sCT as the cause. The mutual information metric employed here may be more sensitive to these effects than other approaches such as chamfer matching. The methodology presented here is generalizable to other anatomical sites and matching algorithms. Further work to assess the impact of sCT on 3D patient verification matching in a range of clinical scenarios with commercially available software is required before implementation of MR-only planning.