PO-0963
The potential role of diagnostic position MRI with deformable registration for radiotherapy planning of HNSCC

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Purpose/Objective: Recently there has been considerable clinical interest in the use of MRI to delineate gross target volumes (GTV) and organs at risk (OAR) for head and neck squamous cell carcinoma (HNSCC). A gold standard (GS) for delineation is considered to be delineation using a dedicated treatment position MRI (MRI-RT) rigidly registered to the planning CT scan, although the MRI-RT is not widely available in many centres. This study aimed to assess whether deformable image registration (DIR) of a diagnostic position MRI (MRI-D) to the planning CT scan is an adequate surrogate for the GS.

Materials and Methods: A prospective pilot imaging study was performed with 3 HNSCC patients (oropharynx, larynx and hypopharynx cancers) who underwent contrast enhanced CT and T1 weighted MRI both in (MRI-RT) and out of (MRI-D) an immobilisation mask. A Radiation Oncologist delineated GTV and OARs (see Table 1) on CT, MRI-RT and MRI-D independently each on 3 separate occasions. Contour comparison (parameters shown in Table 1) was performed with ImSimQA v3.1.5 (OSL, Shrewsbury UK) to assess intra-observer variability of contouring on each imaging modality. Results were compared to the true values of the IEC spheres and of the digital phantom, and to the volumes retrospectively segmented by an experienced radiation oncologist for the 20 clinical cases.

Results: The only parameter that influenced lesion segmentation was minvar, that depended almost linearly on the standard deviation of the voxel values in the region of interest. The parameters used for the analysis were: M=1; a=1; b=0; minvar optimized based on DSC. The agreement between the reference volumes and the result of the segmentation was within 5% for the spherical phantom and within 10% for the digital phantom and the clinical cases.

Conclusions: The described procedure allowed a robust, automatic segmentation of PET volumes to be performed that accurately described reference values. This might form the basis for clinical implementation of the algorithm.

Table 1: Mean contouring comparison results showing intra-observer variability for each imaging modality and accuracy of creating contours using 2 methods compared to the gold standard (GS). The key defines the conformity indices used, the contours produced and the different methods of producing contours.

<table>
<thead>
<tr>
<th>Structure</th>
<th>CT intra</th>
<th>MRI-D intra</th>
<th>MRI-D RT</th>
<th>GS v MRI-D RT</th>
<th>GS v CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>GTV</td>
<td>0.99</td>
<td>1.07</td>
<td>1.18</td>
<td>2.62</td>
<td>4.38</td>
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<tr>
<td>C1-C4</td>
<td>0.78</td>
<td>0.88</td>
<td>0.13</td>
<td>4.79</td>
<td>1.26</td>
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<tr>
<td>C1-C2</td>
<td>0.42</td>
<td>0.12</td>
<td>0.22</td>
<td>2.94</td>
<td>1.17</td>
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<tr>
<td>C6-G6</td>
<td>0.45</td>
<td>0.17</td>
<td>0.19</td>
<td>5.67</td>
<td>1.50</td>
</tr>
<tr>
<td>Brainstem</td>
<td>0.43</td>
<td>0.34</td>
<td>0.26</td>
<td>5.83</td>
<td>0.77</td>
</tr>
<tr>
<td>L parotid</td>
<td>2.93</td>
<td>2.14</td>
<td>1.33</td>
<td>2.57</td>
<td>2.20</td>
</tr>
<tr>
<td>R parotid</td>
<td>3.43</td>
<td>1.28</td>
<td>1.16</td>
<td>2.65</td>
<td>3.09</td>
</tr>
</tbody>
</table>

Key: CGD - Centre of Gravity Distance
DSC - Dice Similarity Coefficient
GTV - Gross Tumour Volume
CT-C6: Spinal cord from superior edge of CT to inferior edge of C6
CT intra - mean intra-observer variability in contouring on CT on 3 separate occasions, taking the mean over all 3 patients
MRI-D intra - mean intra-observer variability in contouring on the diagnostic MRI on 3 separate occasions, taking the mean over all 3 patients
MRI-R intra - mean intra-observer variability in contouring on the treatment position MRI on 3 separate occasions, taking the mean over all 3 patients
GS v MRI-D RT CT - the gold standard (contouring on treatment position MRI and rigidly registering to treatment position CT) comparing to contouring on diagnostic MRI deformably registered to the treatment position CT (simulating radiotherapy department with no dedicated MRI scanner)
GS v CT - the gold standard (contouring on treatment position MRI and rigidly registering to treatment position CT) comparing to contouring on the treatment position CT (simulating radiotherapy department with no access to MRI)

Conclusions: Reproducibility of contouring with MRI was found to be better than with CT indicating that the addition of MRI to the workflow for HNSCC patients is preferable. Contouring on MRI-RT was more accurate than contouring on CT or MRI-D and therefore a preferable workflow. However,
in the absence of dedicated MRI scanners commercial DIR software can facilitate MRI-D into treatment protocols with a benefit in accuracy for GTV delineation demonstrated in this study. Use of MRI-D was limited by the reduced accuracy of DIR with increasing distance from the GTV.

PO-0964
Artefact quantification of liquid and solid fiducial marker in single and dual energy CT with MAR
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Purpose/Objective: The aim of this study was to evaluate changes and artefact reduction and streaking index (SI) for liquid and solid fiducial markers in both single energy CT (SECT) and dual energy CT (DECT) with different metal artefact reduction (MAR) algorithms on a clinical CT-scanner. The artefacts were quantified by severity and SI on SECT and DECT with the eight different MAR algorithms and with no MAR.

Materials and Methods: A total of 16 markers were evaluated, two liquid markers (BioXmark and Lipiodol) with varying volumes (10 to 400 μL) and five solid marker (PolyMark, BeamMarks, FusionCoil, Gold Anchor and a solid gold marker). Each marker was moulded into gelatine in a hollow low density polyethylene rod container with a diameter of 2.5 cm. Imaging was performed with the filled rod container placed inside a CIRS IMRT thorax phantom to represent a lung tumour with a fiducial marker inserted. SECT and DECT-images were acquired for each marker inside their respective container inside the thorax phantom, additionally SECT and DECT images were acquired with gelatine filled container but with no marker to serve as a background. SECT images were acquired at 120 kVp, DECT-images were acquired at 80 kV and 140 kV, and further combined to represent a mono-energetic image at 70 keV. Tube current was selected so that both the SECT and the DECT scans would result in the same dose to the phantom, Slice thickness was 2 mm. A total of eight MAR reconstruction algorithms and one reconstruction without MAR were evaluated for both SECT and DECT. The software used on the CT scanner was a clinical reconstruction without MAR were evaluated for both SECT and DECT.

Results: For the liquid markers, the artefact analysis showed that the SI increased as a function of marker size (volume) in the absence of MAR. The reduction of the SI for the BioXmark worked best for the larger markers (100 to 400 μL) (Table 1). The SI was highest for the two gold markers when no MAR algorithm was used. The MAR algorithm reduces the SI most when the ‘neuro’ MAR algorithm was used for both SECT and DECT (Table 1).

Conclusions: We quantified the SI and artefact severity for a series of both liquid and solid fiducial markers implanted in a simulated tumour in a thorax phantom. We showed that the MAR algorithms reduced both the SI and the artefact severity in both SECT and DECT for all markers but was better on the larger markers (100-400 μL) and the markers with pure gold (Gold Anchor and gold marker). Additional evaluation of the artefact reductions effect on dose distribution in both photon and proton planning is needed.

PO-0965
Deep inspiration breath-hold in left-sided breast radiotherapy or not?: decision based on a single CT-slice
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Purpose/Objective: The mean heart dose (MHD) difference between deep inspiration breath-hold (DIBH) and free-breathing (FB) left-sided whole breast radiotherapy (WBRT) is small for a subgroup of patients. Decision-making on FB or DIBH during treatment planning requires the delineation of the regions of interest on the FB and DIBH CT-scans. This doubles the workload. This study therefore explored the feasibility of DIBH decision-making based on a single CT-slice, acquired prior to full CT acquisition.

Materials and Methods: For 30 left-sided patients treated with tangential field FB-WBRT, the MHDs were calculated. Per patient, 2 FB CT-slices were selected. On each, 2 distances were measured with respect to the individual field setup (Figure): the maximum heart width and the maximum heart length at half the height of the breast volume (MHWBreast and MHLBreast, respectively), MHW and MHL on the CT-slice visualizing the smallest distance between the heart silhouette and the ribs (MWHHeart and MHLHeart, respectively). The (distance,CT-slice)-combination revealing the strongest linear correlation with the MHD was retained as MHD surrogate (S). For DIBH decision-making, a clinically relevant MHD threshold of 3.5 Gy was considered. The corresponding threshold of S (SThreshold) was determined by the Youden index: