joint. As for CBCT acquisition, peak to peak off-plane (orthogonal direction with respect to the plane of rotation) and in-plane vibration (radial direction) for the X-ray tube and flat panel detector measured 0.2 mm and 0.15 mm, respectively.

Calibration of the imaging device, in terms of X-ray tube/flat panel position and panel orientation was within 0.3 residual pixel error. Maximum errors in image guided setup for the static acquisition modality were within 0.8 mm / 0.7 degree. The rotation about the SI axis turned out to be the most critical, due to the absence of a manual initialization in the current implementation.

**Conclusions:** Sub-millimeter accuracy was achieved for patient setup verification in the static projections modality, which is expected to be applied clinically within Spring 2013. Vibrations in CBCT imaging were found to be negligible and preliminary CBCT reconstructions were obtained. System calibration will be extended to the rotational mode to maximize the accuracy in CBCT imaging.

**PD-0411**

**Improvement of four dimensional cone beam CT image quality with iterative reconstruction**

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**Purpose/Objective:** Four-dimensional cone beam CT (4D CBCT) is well known as powerful modality for image-guided radiation therapy. Conventionally, it is reconstructed by sorting the X-ray projection images into each respiratory phase according to a breathing signal using the FDK algorithm based on filtered back projection (FBP). This usually leads to inadequate number of projections in each phase, resulting in low quality 4D CBCT images with obvious streaking artifacts. We tried to improve the image quality for 4D CBCT using the maximum-likelihood convex (ML convex) algorithm based on the iterative reconstruction and compared with the images by FDK in signal-to-noise ratio (SNR) of the reconstructed images.

**Materials and Methods:** We used ML convex algorithm, which has the ability to reconstruct CBCT images from a few number of noisy x-ray projections by taking knowledge of x-ray photon statistics into account. We compared the image quality of 4D CBCT by ML convex with that by FDK using projection images acquired with different rotational speeds by XVI ver. 4.5 (Elekta). Projection images were sorted by 10 phases for both reconstruction algorithms. A phantom study and patient study were performed. The convergence rate and reconstruction accuracy were evaluated using Catphan-600 physical phantom.

**Results:** Figure shows the 4D-CBCT images produced by ML convex and FDK algorithms. The image quality of 4D-CBCT is substantially enhanced by the ML convex algorithm. Streaking artifacts, commonly presented in the image reconstructed by FDK algorithm, are almost suppressed in spite of the small number of projections. Quantitative evaluations indicated that, compared with the FDK results, the ML convex method improves the SNR and reconstructed more accurate CT value.

**Conclusions:** The ML convex algorithm yielded images with higher SNR and more accurate CT value than those produced by FDK algorithm.

**PD-0412**

**Repeatability of diffusion weighted imaging in rectal cancer.**

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**Purpose/Objective:** Serial diffusion weighted MRI (DW-MRI) measurements of the apparent diffusion coefficient (ADC) of rectal tumours are used for rectal cancer response evaluation after neo-adjuvant treatment. Various authors reported a threshold of around 40% increase in ADC values to distinguish between good and poor treatment responders (Kim et al 2010, Lambrecht et al 2012). In this study, we determined the repeatability of DW-MRI to distinguish therapy related response from measurement variations.

**Materials and Methods:** In eighteen patients with resectable rectal cancer receiving short-course radiotherapy MR imaging was performed including two identical DW-MRI sequences in one 1.5T MR protocol before each daily treatment fraction. The intra-observer repeatability, the repeatability within one MRI protocol and between consecutive days were depicted in a Bland-Altman plot. The repeatability coefficient was defined as 1.96 times the standard deviation of the differences between two measurements, expressed as percentage of the mean ADC value or volume.

**Results:** Three females and 15 males with a median age of 59.4 years (range 39.1 – 72.2) were included. The mean tumour ADC value was 1.15x10^-3 mm²/s (SD 0.07x10^-3 mm²), The repeatability coefficient for intra-observer variation was 4.7% (figure A), for measurements within one MRI protocol before each daily treatment fraction. The intra-observer repeatability, the repeatability within one MRI protocol and between consecutive days were depicted in a Bland-Altman plot. The repeatability coefficient was defined as 1.96 times the standard deviation of the differences between two measurements, expressed as percentage of the mean ADC value or volume.

**Table 1:** Results of the Bland-Altman plot repeatability analyses of ADC and volume.

<table>
<thead>
<tr>
<th></th>
<th>Intra-observer</th>
<th>Within protocol</th>
<th>MRI Consecutive days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>10</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Number of measurement pairs</td>
<td>48</td>
<td>85</td>
<td>65</td>
</tr>
<tr>
<td>ADC values</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bias (95% CI), %</td>
<td>0.3 (4.9)</td>
<td>0.7 (-9.1-10.5)</td>
<td>3.2 (-11.0-17.5)</td>
</tr>
<tr>
<td>Repeatability coefficient, %</td>
<td>4.7</td>
<td>9.8</td>
<td>14.3</td>
</tr>
<tr>
<td>Volume</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bias (95% CI), %</td>
<td>0.6 (-5.7-6.8)</td>
<td>-1.1 (10.7)</td>
<td>-12.8 (-24.5-20.4)</td>
</tr>
<tr>
<td>Repeatability coefficient, %</td>
<td>6.2</td>
<td>11.8</td>
<td>22.5</td>
</tr>
</tbody>
</table>
Conclusions: In serial DW-MRI for rectal cancer treatment response evaluation, a repeatability coefficient of 10% has to be considered to account for measurement variations. These variations represent observer judgement and patient and MR spectrometer induced changes.

PD-0413
Assessment of overlap between high FDG-uptake areas in deformed pre-treatment and post-treatment PET scans
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Purpose/Objective: After radiotherapy treatment a tumor residue may remain in the patient, hence showing FDG uptake. If the overlap between this active region and the FDG-uptake area before treatment is high, it might be an indication that the dose delivered was not sufficient to eradicate the tumor. The purpose of this study is to compare the overlap fractions of high FDG uptake areas before and after treatment when the image registration between the two stages is performed using a rigid rotation-translation or using a deformable registration algorithm.
Materials and Methods: For 18 non-small cell lung cancer (NSCLC) patients, two co-registered CT-PET image datasets were available: one scanned before (chemo-)radiotherapy (pre-RT) and one scanned 3 months after treatment (post-RT). First, a rigid registration of the CT datasets was performed; then a volume of interest (VOI) was created based on the PTV, with a 2 cm margin expansion. After this, a deformable registration of the pre-RT CT scan to the post-RT CT scan was performed using the Demons algorithm. The deformation fields resulting from rigid and non-rigid registrations of the CT scan were then applied to the PET scan.
The overlap fractions (OF) between the 34%, 40%, 50% and 60% of SUVmax high uptake areas in the original and deformed pre-RT scan and the 70% of SUVmax high uptake areas (as a surrogate for tumor residue) in the post-RT scan were finally calculated according to the following definition: OF = (overlapping area/smallest volume).
Results: After deformable registration of the pre-RT PET scan, the overlap fractions (mean±SD) of the 34%, 40%, 50% and 60% of SUVmax high uptake areas with the 70% of SUVmax high uptake area in the post-RT scan increased from (67±34)%,(58±33)%,(45±32)%,(37±31)%,(29±30)% to (78±35)%,(74±35%),(65±31%),(54±31%) and (49±31)% respectively. These values are shown in figure1.
Conclusions: In the deformed pre-RT PET-scan higher overlap fractions were reported compared to the non-deformed PET-scan, as expected. In the deformed scan the overlap varies from 78% to 49%, in the original scan this is 67% to 29%. This data supports the hypothesis that the treatment resistant regions are located in the high FDG uptake regions prior to treatment. A voxel-by-voxel analysis is necessary, and will be part of our future work.

PD-0414
Biologic targets identified from dynamic 18FDG-PET and implications for image guided radiotherapy.
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Purpose/Objective: The outcome of biologic image guided radiotherapy depends on the definition of the biologic target. Studies have indicated that both metabolism and perfusion may be relevant targets for such dose escalation approaches. The purpose of the current work was to segment images derived from dynamic 18FDG-PET into perfusion and metabolic target regions. Furthermore, to study the dose distributions in the two targets resulting from dose escalation of either the metabolic or perfusion region.
Materials and Methods: Eleven patients with soft tissue sarcomas were investigated with dynamic FDG-PET. The images were analyzed voxel-by-voxel using a two compartment model, and estimates of perfusion and the metabolic rate where produced as parameter maps. The two image series where segmented using Otsu’s method and exported to a treatment planning system (Oncentra Masterplan v4.1, Nucletron, the Netherlands). Two biological target volumes were defined from respective maps, BTVper and BTVmet, and Dice similarity coefficient was used to compare them. In addition the planning target volume (PTV) was generated from the gross tumor while excluding the respective BTV. A seven field IMRT was set up for a dose painting by contours regime, where PTV was planned for 60Gy and 70Gy to either BTV. Thus, two separate plans were created for each patient with dose escalation of either BTVper or BTVmet.
Results: The volume of BTVper and BTVmet was 209 ± 170 cm3 and 243 ± 147 cm3, respectively, while Dice coefficient for the two BTVs was 0.75 ± 0.13 (population-based mean and s.d.). For each patient, the resulting dose volume histograms (DVHs) of the PTV, BTVper or BTVmet were compared for both plans. For the plan where BTVper is dose escalated, significant differences were found between DVHs of BTVper and BTVmet. For instance, D98 was significantly lower in BTVmet. The mean dose in BTVper was 67 ± 3.2 Gy. For the plan where BTVmet is dose escalated, there were smaller differences between the DVHs. The mean dose in BTVmet was in this case 68 ± 1.7 Gy. The mean dose in the boost target volume was for both instances 69 ± 1.0 Gy.
Conclusions: In conclusion, dose escalation of one of the BTVs results in a partial dose escalation of the other BTV, though coverage was not always complete in the latter region. For the patients in question BTVmet covered on average a larger region than BTVper. Thus, boosting the metabolic region may offer better coverage of aggressive tumor regions. However, if tumor aggressiveness is equally pronounced in the two regions, this should be taken into account in the treatment planning.