A thin plate spline deformation, adapting the original fluence into fluence. In contrast to Ref.1 marker positions are used instead of organ contours. An adapted leaf motion, calculated in Eclipse (Varian Medical Systems, Palo Alto, CA). For the dosimetric step ray tracing is used to calculate the radiological path length, from the source to each marker. Next, the tissue to phantom ratio, is calculated using a fixed 0.5 cm field size. The TPR_{plan}/TPR_{base} median over the different markers rescales the number of monitor units of each beam. For validation a 5 beam sliding window IMRT plan is optimized for the TG119 prostate structures. The phantom is extended with 4 markers and bony anatomy. The initial plan delivers 77Gy(2.2Gy/Fr). Fractions are simulated by applying translations and isotropic scaling using literature values (Table 1). The isotropic expansion is derived from the shrinkage factor, and is used to evaluate the robustness of our approach.

### Results:

Results: Results are compared to plan, and our clinical standard: shifting of the phantom according to the detected marker positions, see Figure 1. The combination of the geometric and dosimetric adaptation results in an identical target coverage as was intended (planX = plan0). The combination of the geometric and dosimetric adaptation results in a similar as our clinical practice (upper row, dashed line (left) vs. solid gray line (right)). All translations have similar magnitude are listed in column 2 and 3. Column 4 indicates on which type and structures the deformations are applied.

<table>
<thead>
<tr>
<th>Type</th>
<th>Magnitude Structures</th>
<th>Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>( -0.4, 2.5, -2.6)</td>
<td>All</td>
</tr>
<tr>
<td>T2</td>
<td>( -4.7, 8.2, -8.0)</td>
<td>Target + Markers</td>
</tr>
<tr>
<td>T3</td>
<td>( -9.0, 14.9, -13.4)</td>
<td>Expansion factor = 0.9</td>
</tr>
<tr>
<td>E1</td>
<td>( -5.7, 1.4, -1.0)</td>
<td>Expansion factor = 1.1</td>
</tr>
<tr>
<td>E2</td>
<td>( -1.2, 2.3, -1.3)</td>
<td>Isotropic expansion</td>
</tr>
</tbody>
</table>

Table 1: Overview of the applied deformations. The type and magnitude are listed in column 2 and 3. Column 4 indicates on which type and structures the deformations are applied.

For S1 and E1 a strongly improved conformity is observed for the adaptation compared to the clinical practice (Figure1). The adaptation ensures a stable, better to our clinical practice for all applied deformations, this indicates better OAR protection.

Conclusions: Target coverage, conformity, and as consequence OAR protection is improved by the presented non-MU preserving adaptation.

References

PO-0849

Dose coverage of lymph nodes in treatments corrected for daily baseline shift of the primary tumour

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Purpose/Objective: Treatment planning and irradiation of lung cancer patients are often based on the mid-ventilation phase in order to minimize planning margins. The primary lung tumour and involved lymph node located in the mediastinum region can have different respiratory patterns. There can be a systematic baseline shift across the entire treatment course between the primary tumour and the lymph node as well as daily random baseline variations. It is desirable to correct for baseline shifts that occurs daily for the primary lung tumour but that might cause a discrepancy between the planned and delivered dose distribution to the lymph node. This study investigates the dose coverage of the lymph node when the entire dose distribution is shifted in accordance with baseline shift of the primary tumour.
Materials and Methods: Standard 3D IMRT treatment plans were created for 10 NSCLC patients with lymph node involvement based on the mid-ventilation phase with a prescribed dose of 66 Gy/33 F. A CTV margin of 1 cm was used around the lymph nodes and was adjusted in order to exclude bone tissue and larger blood vessels. Patient-specific PTV margins of 0.7–1.0 cm were calculated using a probabilistic margin formula and were applied to the CTV. Random day-to-day variations of the baseline shift between the primary tumour and the CTV-node were simulated by blurring the dose distribution relative to the cranial-caudal (CC), left-right (LR) or anterior-posterior (AP) directions with a Gaussian error distribution. Furthermore, a systematic shift between the lymph node and the primary tumour was simulated by displacing the dose distribution relative to the delineated structures with both 0.25 cm and 0.50 cm. Sufficient dose coverage of the involved lymph node was defined as the minimum dose ($D_{\text{min}}$) of the CTV-node was larger than 95% of the prescribed dose for 90% of the patients. Results: The figure shows the minimum dose of the CTV-node for 90% of the patients as a function of the random peak-to-peak variation in the CC direction for the different types of simulations. Dose coverage was sufficient for all data points above 95% of the prescribed dose, which is indicated by the dashed line in the figure. Table 1 summarises the acceptable random peak-to-peak variations in the CC, LR, and AP directions with 0 cm, 0.25 cm and 0.50 cm systematic shifts.

**Table 1: Sizes of random peak-to-peak motions with dose coverage of the CTV-node to 90% of the patients**

<table>
<thead>
<tr>
<th>Day-to-day variation</th>
<th>With 0.25 cm systematic shift</th>
<th>With 0.50 cm systematic shift</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC</td>
<td>2.50 cm</td>
<td>2.25 cm</td>
</tr>
<tr>
<td>LR</td>
<td>3.00 cm</td>
<td>3.25 cm</td>
</tr>
<tr>
<td>AP</td>
<td>3.00 cm</td>
<td>2.75 cm</td>
</tr>
</tbody>
</table>

Conclusions: Dose coverage of the CTV-node can be achieved with large random peak-to-peak variations between the primary tumour and CTV-node in treatments corrected for daily baseline shift of the primary tumour. With the introduction of a systematic shift during the treatment course the random peak-to-peak variation was only slightly reduced. However, large systematic shifts are undesirable and should justify a re-planning of the treatment.

PO-0850
Accuracy of online position verification in breast radiotherapy with two orthogonal kV fields
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Purpose/Objective: 3D position verification in breast radiotherapy with kV-CBCT is very accurate but time-consuming, especially in gated breast radiotherapy. Due to the need for uniform position verification in non-gated and gated conformal breast radiotherapy, the accuracy of the patient position adjustment based on the online matching of two orthogonal kV fields was investigated.

Materials and Methods: Twenty breast cancer patients and 20 patients treated for breast cancer in combination with internal mammary-medial supraclavicular (IMMS) lymph node irradiation, i.e. locoregional breast treatment, were included in the study. Each treatment was performed on a Varian Clinac 2100C/D linear accelerator equipped with an amorphous-silicon EPID and an OBI system. The patient positioning and isocenter shift were checked with online paired kV-kV matching using the ribs close to the isocenter. One of the orthogonal kV fields was parallel to one of the tangential field directions (see figure). Only translations were adjusted. The new patient position was verified during 5 fractions by kV imaging of both tangential breast fields and kV imaging of the MS-field. All images were matched in Offline Review (Varian Medical Systems, Inc.) using bony anatomy. The differences for each tangential field were reported as $\Delta$CLD (Central-Lung-Distance, i.e. the distance between the deep field edge and the interior chest wall at field central axis), and $\Delta$Cranio(Caudal). The differences for the MS-field were reported as $\Delta$Vert, i.e. $\Delta$Vertical, $\Delta$CC and $\Delta$Lat(eral). The range of the patient mean errors, the percentage of the patient population with an absolute value of the mean error larger than 2 mm, the population mean, population systematic error and population random error were reported.

Results: For breast cancer treatment with and without IMMS irradiation, a mean CLD error ranging from -1 mm to 2 mm and from -1 mm to 3 mm, respectively, was found. Only 5% of the breast cancer patients had a mean $\Delta$CLD $>$ 2 mm. The patient mean $\Delta$CC ranged from -3 mm to 3 mm and from 0 mm to 3 mm for the breast treatments and the locoregional breast treatments, respectively. For 10% of the patients, the mean $\Delta$CC was larger than 2 mm, irrespective of the treatment. None of the population systematic errors were larger than 1 mm and none of the population random errors were larger than 2 mm, irrespective of the patient group (see table). The population systematic and random errors measured in the MS-field were smaller than 1 mm for all three directions (see table).

Conclusions: The new position verification protocol is appropriate for accurate, uniform and quick 3D position verification in non-gated (locoregional) breast radiotherapy and easily extendible to gated breast radiotherapy. An important property of the protocol is the low imaging dose to both the target volume and the healthy tissue thanks to the combination of the kV imaging and the field orientation.

PO-0851
Dosimetric effects of small setup uncertainties for various intensity modulated proton therapy delivery methods
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Purpose/Objective: Uncertainties in patient positioning are a crucial issue to be considered when treating patients with particles. In this study we aim to quantify the effect of small patient misalignment for different proton dose delivery techniques.

Materials and Methods: We have investigated three different delivery techniques: 3D spot-scanning (3DSS), distal edge tracking (DET) and modulated proton therapy delivery methods.