Results: The resulting displacement average after analyzing 50 treatments was less than 1 mm along the three axes: $x = (0.62 \pm 0.51) \text{ mm}$, $y = (0.83 \pm 0.63) \text{ mm}$, $z = (0.65 \pm 0.59) \text{ mm}$. These setup displacements have remained under 3 mm in 100% of treatments. These results achieve the International Commission on Radiation Units and Measurements (ICRU) recommendations regarding the setup margin to compensate the immobilization and positioning errors.

Conclusion: The type of patient immobilization devices and their contribution in the setup errors must be taken into account for IMRT. Additionally, the use of different image-guidance systems can significantly alter the size of the required margins. Lorca Marin customized silicone molds are 3-points immobilization with frontal and mental reinforcement and 3.2 mm thickness. 3-standard references were marked on the surface of the mask and on the middle chest of the patient for accurate positioning every day. Cone-beam computed tomography scan to verify online the position was performed during 5 consecutive days and after, weekly cone-beam (CBCT) until the end of the treatment. After weekly matching process using automated soft-tissue registration, translational movements along the three axes ($x$, $y$, $z$) were collected and the average for each treatment and each axis was calculated. Displacements’ mean of the 50 averages and the standard deviations were analyzed and compared.

Results: Attenuation measurements is shown in the image, and is lower than 4% for orthogonal incidence. No artifacts on MRI image were observed. Reproducibility between MRI and CT simulation was better than 1 mm in all cases studied, based in direct versus automatic registration. The mean and standard deviation of shifts for the CompMRI board versus conventional board are shown in table 1. An analysis of variance differences using a Fisher test gives statistically significant differences between variances of two groups ($p < 0.01$). The distributions of the absolute displacements were similar in both groups.

Conclusion: Our data show that the C-MRI board have low attenuation and a better immobilization and reproducibility than the conventional board. Position reproducibility from MRI simulation and CT simulation was excellent. Combination of MRI compatible board with silicone fixation provided robust immobilization and can be safely used for MRI-CT registration procedures eliminating the use of deformable and complex software algorithms. These data could be used for a potential reduction of margins for the PTV.

Results:

<table>
<thead>
<tr>
<th>C-MRI</th>
<th>$x$ (mm)</th>
<th>$y$ (mm)</th>
<th>$z$ (mm)</th>
<th>Roll ($^\circ$)</th>
<th>Tilt ($^\circ$)</th>
<th>Pitch ($^\circ$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8 ± 0.6</td>
<td>0.3 ± 0.9</td>
<td>-1.0 ± 1.2</td>
<td>0.7 ± 0.7</td>
<td>0.1 ± 0.5</td>
<td>-0.1 ± 0.5</td>
<td>-0.2 ± 1.0</td>
</tr>
<tr>
<td>Conventional</td>
<td>0.8 ± 0.7</td>
<td>-1.7 ± 0.9</td>
<td>-1.0 ± 1.2</td>
<td>0.4 ± 1.2</td>
<td>0.1 ± 1.2</td>
<td>-0.2 ± 1.0</td>
</tr>
</tbody>
</table>

Conclusion: Our data show that the C-MRI board have low attenuation and a better immobilization and reproducibility than the conventional board. Position reproducibility from MRI simulation and CT simulation was excellent. Combination of MRI compatible board with silicone fixation provided robust immobilization and can be safely used for MRI-CT registration procedures eliminating the use of deformable and complex software algorithms. These data could be used for a potential reduction of margins for the PTV.

Material and Methods: Five patients with cervical cancer without uterine fundus involvement were scanned by 2.5 mm slice thickness CT after a 30 minute, 500 cc water consumption. PET/CT and MR fusion was performed to delineate GTV and used as surrogates to see the potential motion of uterus at different imaging modalities due to bladder and rectal fillings. CTV1 was contoured to include GTV+cervix+uterus modified to be covered in simulation CT, PET/CT and MR. PTV margin of 15 mm was added according to guidelines. VMAT IMRT plans were performed to give 45 Gy in 25 fractions. Image guidance with daily KV CBCT was performed on TrueBeam STx and Trilogy linacs (Varian, Palo Alto) throughout the external phase of the treatment, which was followed by HDR brachytherapy. When the CTV1 was missed on CBCT, the bladder filling was modified accordingly; CBCT was repeated and treated after ensuring the coverage.

Results: Uterine fundus was contoured on a total of 125 CBCT images of 5 patients. Overall on 24 of 125 fractions (19.2%) CTV1 was out of PTV. Mean volume of CTV1 out of PTV was 0.92 cc (range 0.02-2.78 cc). Mean Dmin for fundus was 133 cGy when the CTV1 was out of PTV. Mean volume of CTV1 out of PTV was 0.92 cc (range 0.02-2.78 cc). Mean Dmin for fundus was 133 cGy when the CTV1 was out of PTV, while it was 176 cGy when CTV1 was covered on CBCT.

Conclusion: Although the inclusion of the uterine fundus in the CTV for the definitive treatment of cervical cancer without fundus involvement is controversial, potential microscopic spread is a concern. Rigorous bladder filling is a way to minimize the interfraction motion of the uterus,
however daily image guidance with CBCT still showed a residual replacement of the uterus in up to one fifth of the fractions in this study. Further studies on managing this problem like adaptive treatment by using plan of the day concept to cover the CTV are ongoing.

EP-1791
Improving patient posture reproducibility by using the predicted couch position and tight tolerances
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Purpose or Objective: With online imaging inter-fraction motion is very small. However, when a patient is wrongly positioned on an immobilisation device, the patient posture cannot be corrected with a simple couch shift or rotation. The couch position indicates the accuracy with which the patient is positioned with respect to the immobilisation device on a day-by-day basis. The purpose of this work is to improve patient posture reproducibility by predicting the couch position before the first treatment (preventing a systematic error in couch position), and by using this couch position at the LINAC more directly than only for verification purposes.

Material and Methods: All patients with a planning-CT are treated with an immobilisation device attached to the treatment couch. A software tool, “planinfo”, predicts the couch position from the geometrical information of the planning-CT in the EPD and the isocentre coordinates in the treatment plan. Before the treatment session the couch is positioned at the predicted couch position of the patient set-up point, given in the set-up notes. The patient is instructed to move until the lasers align with the patient tattoos. We do not need to have the lasers exactly on the tattoos, because we perform an online imaging procedure. Patient rotations with respect to the lasers are to be avoided. Next, the couch is shifted to the isocentre, an online imaging procedure is performed and the patient is treated. We do not use the couch position at the first treatment fraction as a reference, preventing systematic errors in couch position.

Results: Table 1 shows the tolerances that we use for the 5 immobilization devices, the average difference between the predicted and the treated couch position in the first half of 2015 and the standard deviation of the differences for all treatment fractions in this period. These values are better than the couch position values reported by others in comparable with literature [2,3], because the masks more rigidly relate the patient position to the couch than other immobilisation devices. However, with our method we do not need to mark any lines or points on the current tolerance tables. This is about 1 % of all treatment fractions. For palliative treatments with its own immobilization device (home-made head base with a cushion) it is about 5 %.

Conclusion: We have improved the patient setup considerably. Currently, all patients with a planning-CT are treated according to the method described above. We use tight tolerances to ensure patient posture reproducibility.

EP-1792
Pre-fraction shift and intra-fraction drift of the prostate due to perineal ultrasound probe pressure
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Purpose or Objective: In image guided radiotherapy of the prostate, during trans-abdominal ultrasound imaging, the pressure applied by the ultrasound probe against the abdomen has been shown to displace the prostate. In this study trans-perineal imaging is evaluated. The impact of varying probe pressure on pre-fraction shift and intra-fraction drift of the prostate is measured.

Material and Methods: Two separate experiments were performed: Before treatment (10 patients) varying ultrasound pressure was applied to the perineum. In a series of scans, the probe was moved against the perineum and the corresponding shifts of the prostate were detected. Linear regression was performed. During treatment (15 patients, 273 fractions) intra-fraction drift of the prostate was tracked (total of 27 hours and 24 minutes).

Results: Per 1 mm shift of the ultrasound probe in cranial direction, a displacement of the prostate by 0.42±0.09 mm in cranial direction was detected. The relationship was found to be linear (R²=0.97) and highly significant (p=0.0001). After initial contact of the probe and the perineum (no pressure) a shift of the probe of about 5 to 10 mm was typically necessary to achieve good image quality, corresponding to a shift of the prostate of about 2 to 4 mm in cranial direction. There was found also a systematic (p=0.03) shift of <0.1 mm in anterior direction, but not significant shift in lateral direction (p=0.14). The compression of the tissue between probe and prostate was well visible in consequent scans. During treatment, the prostate was drifting at a rate of -0.075 mm per minute in cranial direction on average. While small, this systematic trend on the longitudinal axis was significant (p=0.0014). There was no significant trend on neither the lateral nor the vertical axis (p=0.62 resp. p=0.19). Also, due to the perineal probe, the prostate had fewer degrees of freedom in caudal direction.

Conclusion: The pressure applied by a perineal ultrasound probe has a quantitatively similar impact on prostate displacement as trans-abdominal imaging. Shifts are predominantly in cranial direction (typically 2 to 4 mm) with some component in anterior direction (typically <1 mm). Slight probe pressure can improve image quality, but excessive probe pressure can distort the surrounding anatomy and potentially move risk organs closer to the high dose area. Tentatively, probe pressure could also have beneficial effects in stabilizing the prostate.