Purpose or Objective:

Management of inter-fraction patient movement for SBRT treatments without an on-site 3D imaging.

Material and Methods:

A group of 132 SBRT treatments (1 to 5 fractions of 6.5 to 20 Gy each) were retrospectively analyzed. From this, we have considered a total of 227 fractions suitable for analysis.

Table 1. Estimated coefficients and correlation coefficients $R^2$ based on linear regression between the EPID and the CBCT registrations found by the CBCT. While an automatic matching method of the EPID potentially could improve on the manual matching.

Conclusion: EPID registrations generally underestimated the registrations found by the CBCT. While an automatic matching method of the EPID potentially could improve on this, the automatic matching method evaluated in the current study showed inferior performance compared to manual matching.

Figure 1. Bland-Altman Plot of the difference between EPID and CBCT registrations. In a) the EPID images were matched manually in iView and in b) the match was performed automatically using IGPS. The vertical solid line indicates the mean difference and the vertical dashed lines the limits of agreement. Linear regression was performed to test for trends in the differences. Estimated coefficients for the linear regression and the corresponding p-value for the null hypothesis that the slope = 0 are shown.

Table 1. Estimated coefficients and correlation coefficients $R^2$ based on linear regression between the EPID and the CBCT registration using the model: $EPID = a \times CBCT + b$. Standard errors (SE) are given in brackets.

Results: Isocenter position had to be corrected in the treatment room as showed in the table below, for all locations considered:

Conclusion: For lung cases, we needed to reposition 23% cases less than without pre-fraction CT scan, 3% less for abdomen cases, and 25% more for the rest, not considered due to the low statistic (24 cases). The pretreatment CT scan is very time consuming both for the Radiation Oncology and Radiation Physics departments, but on-site positioning is easier and so the treatment can be performed more comfortably for the patient.

Purpose or Objective: To validate the methodology we use for managing the inter-fraction patient movement in stereotactic body radiotherapy (SBRT) treatments. This methodology consists of the use of internal markers, one CT scan per fraction, and the portal vision system every fraction.

The treatment technique was mainly 3DRT, using two Varian linear accelerators (clinac 2100C / 2100CD), both with Portal Vision AS500 - IAS5, Philips Pinnacle v9.8 treatment planning system (TPS), and Mosaiq (Elekta) Record and Verify (R&V). Adequate immobilization systems were used and internal fiducials marks were inserted.

A new CT scan was performed before each fraction in 172 cases, where treatment volumes and organs at risk were delineated by the Physician (after registration with the initial one). Treatment plan was recalculated to verify dosimetric consistency, and the isocenter position was updated according to the new anatomy. For setting purposes, a new set of orthogonal RDR images (gantry 0° and 90°) were sent to the PV. The remaining 55 cases were treated using the initial CT and were used here for validation proposes.

On the couch, the patient was initially aligned on the CT marks, and then it was moved to the updated isocenter position. Two Portal Images (orthogonal, 0° - 90°) were done and registered with the corresponding RDR using the fiducial marks. If the displacements were greater than 0.5mm, the patient was moved.

We have performed this study for different anatomy locations (118 lung cases, 85 abdomen cases and 24 others cases), expecting different results.

Results:

Adequate immobilization systems were used and internal fiducials marks were inserted. The pretreatment CT scan is very time consuming both for the Radiation Oncology and Radiation Physics departments, but on-site positioning is easier and so the treatment can be performed more comfortably for the patient.

Also, the dosimetric verification prior to each fraction allows us to assess the suitability of the new displacements to meet the clinical goals.

Conclusion: For lung cases, we needed to reposition 23% cases less than without pre-fraction CT scan, 3% less for abdomen cases, and 25% more for the rest, not considered due to the low statistic (24 cases). The pretreatment CT scan is very time consuming both for the Radiation Oncology and Radiation Physics departments, but on-site positioning is easier and so the treatment can be performed more comfortably for the patient.
Couch coordinates and set-up tolerance levels

An immobilization device-based procedure to predict reconstructed volumetric cone-beam CT image quality. The new kV flexmap could improve the skewness. The new kV flexmap could improve the skewness. The MV system. The algorithm also allows for extraction of the skewness and panel-tilt data, but they are not presented in the Table. The kV system was found to have high reproducibility.

Results: The results of six gantry rotations are listed in Table 1. The cross-plane sag of the kV source was found to be approximately 10 times larger than the sag of the gantry head, while the in-plane sag was almost two times larger. The cross-plane source sag corresponds to a gantry angle displacement of up to 0.3 degrees. The kV panel sag was comparable to the sag of the MV panel. The kV source-to-panel distance variation was almost half the amount for the MV system. The algorithm also allows for extraction of the skewness and panel-tilt data, but they are not presented in the Table. The kV system was found to have high reproducibility.

Conclusion: The measurements and analysis in this study confirm the sag pattern of the CBCT unit components. The Elekta kV flexmap do not compensate for all sag contributions such as panel rotation and tilt, source sag, and radial source-panel distance variations. A new kV flexmap is suggested for compensation of some additional flex contributions with the exception of panel rotation which cannot be measured in our setup or separated from skewness. The new kV flexmap could improve the reconstructed volumetric cone-beam CT image quality.

EP-1803
An immobilization device-based procedure to predict couch coordinates and set-up tolerance levels

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Purpose or Objective: We propose and evaluate a simple method to predict absolute couch coordinates (ACC) based on different landmarks identified on two immobilization devices. We analyze the inter-observer variability of the method and establish set-up tolerance levels.

Material and Methods: Two immobilization devices were evaluated in this study: the Portrait Head and Neck Device by Qfix and the PosiRest-2 by Cicvo, used in HN and thorax/breast positioning respectively. Each device was indexed on the treatment table (Varian Exact Couch) and one plastic screw was matched to the room lasers were the ACC were read. The isocenter ACC were obtained by taking simple distance measurements on the CTR from isocenter to the screw. We studied the inter-observer variability by having 5 different observers repeating all measurements. A total of 46 patients were analyzed: 22 breasts, 12 lungs and 12 HNs. All patients were set-up according to a NAL-3 protocol. A total of 1020 treatment sessions were recorded. We compared predicted couch positions to treatment couch positions acquired after the systematic error correction (4th day). We established device and location specific tolerance levels to accommodate 95% of all sessions. We finally studied if there was any correlation relating these differences and patient random set-up error.

Results: The average of the standard deviations of predicted positions among the 5 observers was <2 mm for all coordinates (vert, lat, long) and devices. There was strong correlation between almost all predicted positions and the systematic error corrected positions (r=0.9) but for the lateral coordinate prediction on the HN device (cause by having small values (<7 mm)). No correlation was found between predicted vs. corrected deviations positions and random error. Thus, this difference cannot be used to predict difficult to set-up patients. In order to accommodate 95% of all treatment sessions couch positions the following tolerances (2σ) were obtained (in mm) for (vert, lat, long): breast (12, 23, 30); lung (12, 20, 22); h (7, 7, 7).

Conclusion: Our designed procedure based on immobilization device landmarks offers a simple and reproducible method to correctly predict absolute isocenter coordinates. Difficult to set-up patients (large random error) cannot be isolated from the differences between predicted and treated positions on a specific day. However, the procedure allows obtaining tight set-up tolerance levels to prevent gross set-up errors.

EP-1804
A comparative analysis of prostate positioning guided by transperineal 3D ultrasound and cone beam CT

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Purpose or Objective: The accuracy of the Elekta ClarityTM transperineal three-dimensional ultrasound system (3DUS) was assessed for prostate positioning and compared to seed- and bone-based positioning in kilovoltage cone beam computed tomography (CBCT) during a definitive radiotherapy.

Material and Methods: The prostate positioning of 7 patients, with fiducial markers implanted into the prostate, was controlled by 3DUS and CBCT. In total, 177 transperineal ultrasound scans were performed and compared to bone-matches and seed-matches in CBCT scans. Setup errors detected by the different modalities were compared. Using seed-match as reference, systematic and random errors were analysed, and optimal setup margins were calculated for 3DUS.

Results: The discrepancy between 3DUS and seed-match in CBCT was 0±1.7 mm laterally, 0.2±2.0 mm longitudinally and 0.3±1.7 mm vertically and significant only in vertical direction. Using seed-match as reference, systematic errors of 3DUS were 1.2 mm laterally, 1.1 mm longitudinally and 0.9 mm vertically, and random errors were 1.4 mm laterally, 1.8 mm longitudinally, and 1.6 mm vertically. Using the optimal margin recipe by van Herk, the optimal setup margins for 3DUS were 3.9 mm for prostate, 4.0 mm and 3.3 mm in lateral, longitudinal and vertical directions respectively.

Conclusion: Transperineal 3DUS is feasible for image guidance for patients with prostate cancer and seems comparable to fiducial based guidance in CBCT in the retrospective study. While 3DUS offers some distinct advantages such as no need of invasive fiducial implantation and avoidance of extra radiation, its disadvantages include the operator dependence of the technique. Further study of transperineal 3DUS for image guidance in a large patient cohort is warranted.