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.

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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 literature, because we do not shift the couch to align the patient with the lasers, but we shift the patient in the immobilization device to achieve this. Radiation therapists indicate that it is more straightforward to position the patient with this method. For head and neck the values are comparable with literature [2,3], because the masks more rigidly relate the patient position to the couch than other immobilization devices. However, with our method we do not need to mark any lines or points on the immobilisation mask. Table 1 also shows the number of overrides with our 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 %.

Table 1: Comparison of the difference in predicted and treated couch position for the first half of 2015.

Immobilization	Fractions	Override percentage	Direction	Tolerance (mm)	Average (mm)	Standard deviation (mm)
Head and Neck	3389	0.9 %	Vertical	10	0.0	2.1
			Longitudinal	10	2.2	2.8
			Lateral	10	1.3	3.1
Thorax	6062	1.0 %	Vertical	10	1.1	2.8
			Longitudinal	15	-1.0	5.7
			Lateral	15	-0.2	4.6
Mamma	8529	0.4 %	Vertical	10	0.2	3.4
			Longitudinal	15	0.1	4.3
			Lateral	15	-0.6	4.1
Pelvis	7766	1.2 %	Vertical	10	1.1	3.7
			Longitudinal	15	-1.5	4.3
			Lateral	15	-0.3	5.1
Palliative	766	5.9 %	Vertical	10	0.5	2.5
			Longitudinal	15	-0.1	6.2
			Lateral	15	-0.9	6.6

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.

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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 (R^2=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.