Positioning accuracy of two electromagnetic positioning systems in radiotherapy of prostate cancer

A. Vanhanen*[1,2], M. Kapanen[1,2]

[1] Department of Oncology, Unit of Radiotherapy, Tampere University Hospital, POB-2000, 33521 Tampere, Finland
[2] Department of Medical Physics, Medical Imaging Center, Tampere University Hospital, POB-2000, 33521 Tampere, Finland
*antti.vanhanen@pshp.fi

OBJECTIVES

Inter- and intra-fraction motion of the prostate is a well-known phenomenon that has to be corrected for accurate target localization in prostate cancer radiotherapy. The aim of this study was to investigate the positioning accuracy of two commercial electromagnetic (EM) positioning systems, RayPilot (Micropos Medical AB, Sweden) (RP) and Calypso (Varian Medical Systems, USA), compared to kilovoltage (kV) image guidance as the golden standard.

METHODS

RP transmitter as well as three gold markers were implanted into the prostate of 22 patients. RP positioning data was collected throughout the treatment fractions and target localization was based on two orthogonal kV images (kV-IGRT) using gold markers as fiducials. Calypso localization and tracking was used for 26 patients and the localization was confirmed by kV-IGRT using three Calypso transponders as fiducials. Couch shifts suggested by the RP and Calypso readings of the isocenter offset at the time points of kV-IGRT were compared to the couch shifts suggested by the kV-IGRT. The mean and standard deviation (SD) of the differences between couch shifts in anterior-posterior (AP), superior-inferior (SI) and left-right (LR) directions were determined. The Bland-Altman method was used to analyze the agreement between the EM systems and kV-IGRT. The 95% limits of agreement (LOA) were determined. Differences larger than ±2 mm were considered unacceptable. A total of 582 RP fractions and 335 Calypso fractions were analyzed.

Table 1. The results of the Bland-Altman analysis: differences in couch shifts between RayPilot and kV imaging, and between Calypso and kV imaging. Positive values in AP-, SI- and LR-axes represent couch shifts towards anterior, inferior and left directions. All values are given in mm. Also presented are the percentages of differences within ±2 mm.

	AP		SI		LR	
	RayPilot	Calypso	RayPilot	Calypso	RayPilot	Calypso
Mean difference	0.3	-0.2	-2.2	0.1	-0.0	-0.1
SD	2.2	0.6	2.4	0.5	1.1	0.4
Upper LOA	4.7	1.1	2.5	1.2	2.0	0.8
Lower LOA	-4.0	-1.5	-6.8	-0.9	-2.0	-0.9
≤ 2 mm [%]	65.4	98.6	45.3	99.6	95.0	100.0

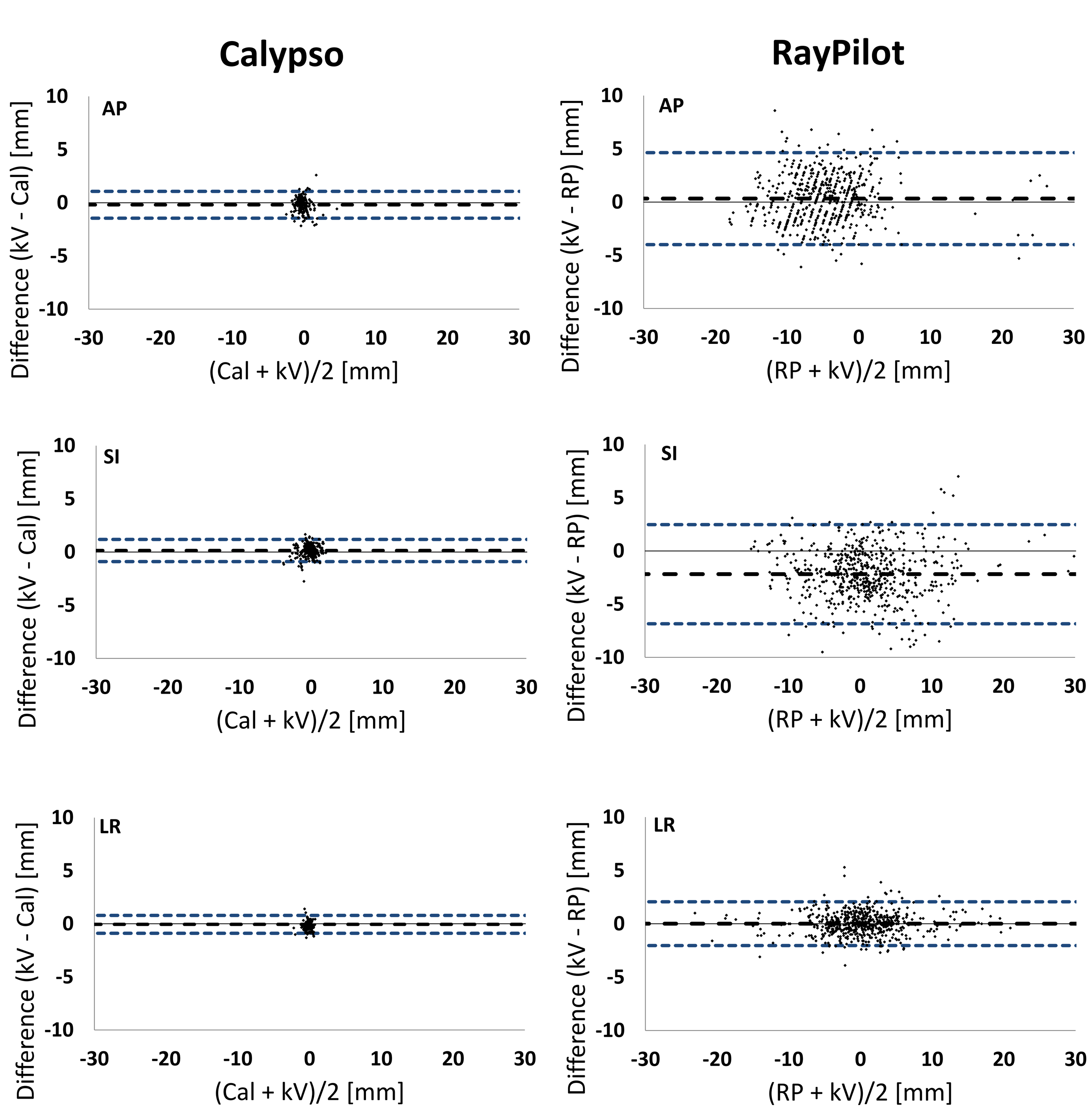

Figure 1. Bland-Altman plots of the difference between Calypso and kV imaging based couch shifts and between RayPilot and kV imaging based couch shifts. Black dashed line presents mean difference and blue dashed lines upper and lower 95% limits of agreement.

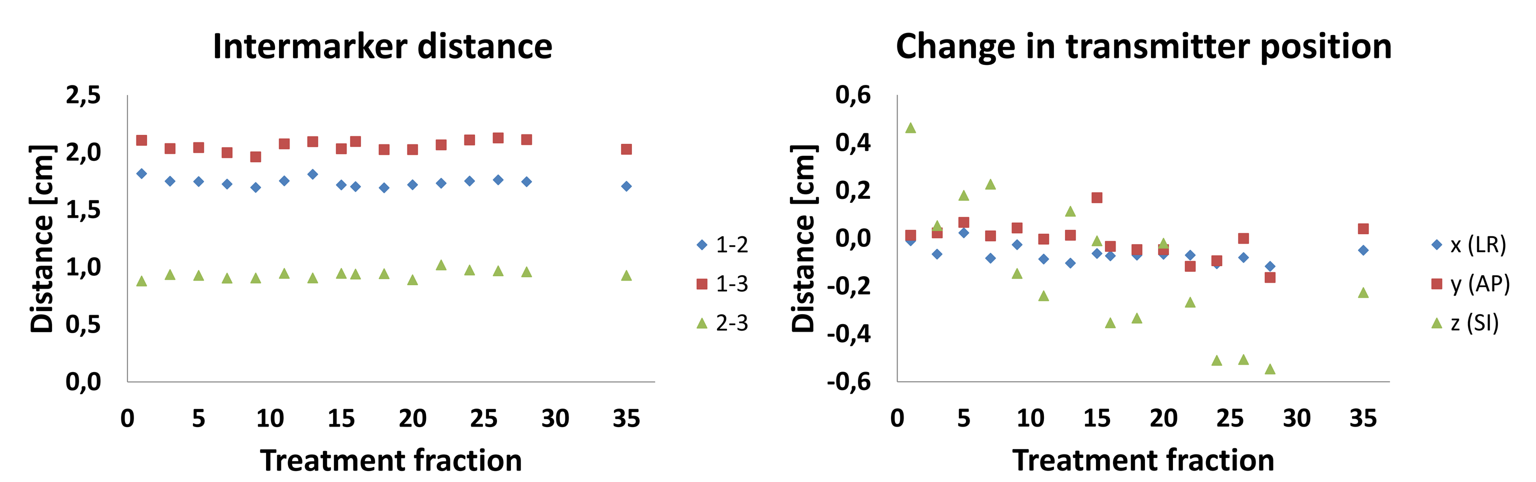

Figure 2. On left: intermarker distances for one patient during the treatment course. On right: change in the distance between RP transmitter and the geometrical center point of the gold seed markers for the same patient. Positional variability of the transmitter was large in general, especially in SI direction.

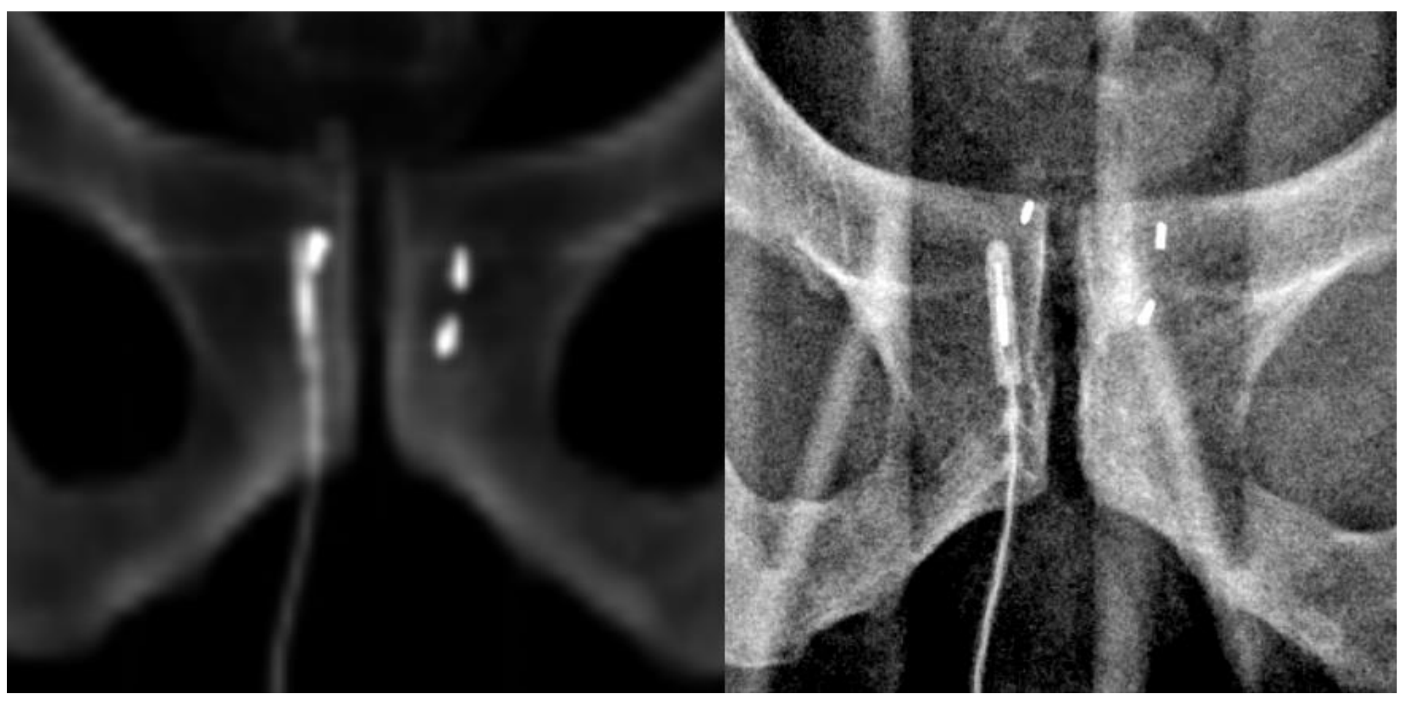

Figure 3. An example of large caudal migration of the RP transmitter. On left: reference DRR-image of the RP transmitter and gold seeds, reconstructed from the planning CT. On right: corresponding kV-image at the 28th treatment fraction. 5 mm caudal migration of the transmitter can be seen between the images.

RESULTS

Results are presented in table 1 and figure 1. Differences in the couch shifts were largely dispersed and large systematic error in mean difference was seen in SI direction between RP and kV-IGRT. Differences in couch shifts between Calypso and kV-IGRT were small. Bland-Altman analysis (**fig.1**) shows that the RP did not agree well with kV-IGRT: the LOAs were ±4.3, ±4.7 and ±2.1 mm around the mean for AP, SI and LR directions, respectively. Calypso agreed well with kV-IGRT having LOAs of ±1.3, ±1.0 and ±0.8 mm around the mean for AP, SI and LR directions, respectively. Large variability was seen in the RP transmitter position during the treatment course (**fig. 2 and 3**).

CONCLUSIONS

Compared to kV-IGRT, positioning accuracy of Calypso outperformed the RP. RP positioning accuracy was affected by the migration of the transmitter caused by pulling forces it was exposed to via transmitter cable and deformations of the prostate caused by varying filling of the rectum and the bladder affecting on the relative position between the transmitter and isocenter. Results indicate that Calypso could replace kV-IGRT in the inter-fraction motion management of prostate radiotherapy but positioning with RP should be verified by kV or CBCT imaging, preferably with fiducial markers.

ESTRO37 PO-0953
Physics track: Inter-fraction motion management (excl. adaptive radiotherapy)
Antti Vanhanen
DOI: 10.3252/pso.eu.ESTRO37.2018
Poster presented at: