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Inter and intrafraction setup error for breast cancer patient with AlignRT SGRT system

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Background and purpose

AlignRT is a SGRT system for patient positioning and intrafracion monitoring [1]. We investigated the accuracy of AlignRT system for positioning procedure and estimated SGRT intrafraction setup error in breast cancer patient.

Material and Methods

446 breast cancer patients (1746 fractions) subjected to SGRT (AlignRT) radiation therapy were included.

Patients were positioned and monitored with AlignRT system. A CBCT was acquired during the first three fractions of each treatment and if the translational corrections were smaller than 5 mm, the subsequent treatments were delivered without performing the CBCT. An additional CBCT scan was acquired during the fraction in the middle of treatment.

For each fraction, we collected the CBCT shift corrections ($Shift_{CBCT}$) and extracted AlignRT signals. These signals represent the difference between the virtual simulation body surface and the actual patient position. After signal postprocessing, we defined three intervals of interest (Figure 1): Interval1 ($Shift_{AlignRT}$), after AlignRT positioning; Interval2, at the beginning of the first field; Interval3, at the end of the last field.

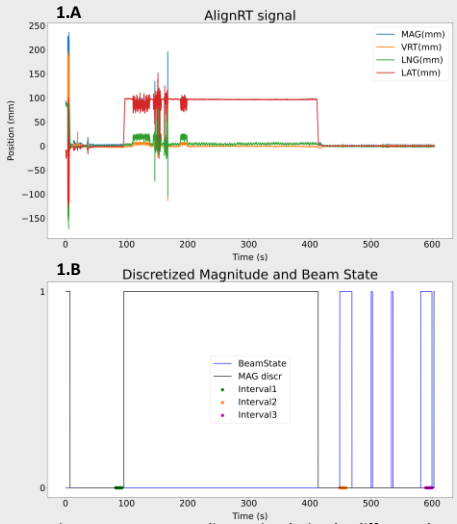

Figure 1. Figure 1.A represents AlignRT signals, i.e the difference between the virtual simulation body surface and the actual patient position for Vertical (orange), Longitudinal (green) and Lateral (red) directions. The Magnitude plot (blue) is given by the RMS of each of the translational components. After signal postprocessing, the Magnitude plot has been discretized (black in Figure 1.B), 0 for Magnitude smaller than 20 mm and 1 for Magnitude greater than 20 mm, in order to find the four 10s intervals of interest. The mean over the 10 seconds of the signal in each direction has been considered for subsequent calculation. Figure 1.B displays also the Beam State (blue) of each fraction field, 0 for beam off, 1 for beam on.

Results

We compared the shifts measured by AlignRT system during patients setup and by CBCT. Results are collected in Table 1.

		VRT (mm)	LNG (mm)	LAT (mm)
Shift AlignRT - Shift CBCT	mean	-0.4	0.7	0.0
	std dev	2.2	2.7	2.3
|Shift AlignRT - Shift CBCT|	mean	1.8	2.1	1.7
	std dev	1.4	1.7	1.5
Cohort Percentiles	90° perc	3.7	4.2	3.6
	25° perc	0.7	0.8	0.6

Table 1. Translational differences between AlignRT and CBCT in Vertical (VRT), Longitudinal (LNG) and Lateral (LAT) directions.

The systematic and random errors over the whole cohort of patients are ≤ 2 mm in each translational direction, as reported in Table 2. We found about 5 mm target margins using the Van Herk formula [2].

	VRT (mm)	LNG (mm)	LAT (mm)
Systematic Error	1.9	1.9	1.9
Random Error	1.8	2.0	1.8
Van Herk margins	5.13	5.10	5.07

Table 2. Systematic error, random error and margins computed in Vertical (VRT), Longitudinal (LNG) and Lateral (LAT) directions.

	VRT (mm)	LNG (mm)	LAT (mm)
mean	-0.2	-0.3	0.0
std dev	0.7	0.8	0.7
90° perc	1.2	1.2	1.0
25° perc	0.2	0.2	0.1

Table 3. Intrafraction motion for Vertical (VRT), Longitudinal (LNG) and Lateral (LAT) directions.

Intrafraction movements were computed as the difference between Interval3 and Interval2, and the mean over the whole cohort of patients resulted in less than 1 mm in each translational direction (Table 3).

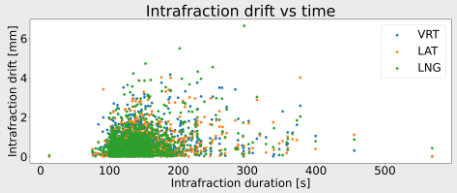

Figure 2. Scatter plot for correlation between intrafraction motion and treatment duration. It can be noted that the points related to large intrafraction displacements are few.

We further investigated the correlation between intrafraction movement and treatment duration (no statistically significant correlation was found in any direction, as shown in Figure 2) and the differences in intrafraction movements between the first session and the followings (no statically significant difference were appreciated in any direction, as displayed in Figure 3).

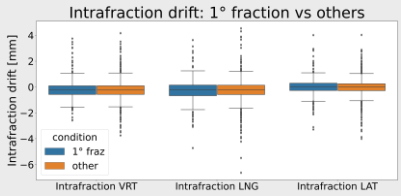

Figure 3. Boxplot for intrafraction motion comparison between first fractions (blue) and all the other fractions (orange) for each patient.

Conclusion

We found that margins for target computed with AlignRT system are comparable with those currently employed and intrafraction movements are overall acceptable, except for some patients for which personalized measures must be considered.

Given the agreement between AlignRT and CBCT systems, we believe that, after the first fraction, it should be possible to avoid the CBCT for most of future breast cancer treatments.

References
1. Heinzerling JH, et all. Use of surface-guided radiation therapy in combination with IGRT for setup and intrafraction motion monitoring during stereotactic body radiation therapy treatments of the lung and abdomen. J Appl Clin Med Phys. 2020; 21(5):48-55. doi: 10.1002/acm2.12852.
2. Van Herk, M. Errors and margins in radiotherapy. Semin. Radiat. Oncol. 2004; 14 (1):52-64. doi: 10.1053/j.semradonc.2003.10.003.