Pilot Study for Tattooless-Based Accelerated Partial Breast Irradiation (APBI)

Hao-Yun Hsu, Yulin Song, Wang-Chia Ko, Boris A. Mueller, Paul Tamas, Lior Z. Braunstein
Memorial Sloan Kettering Cancer Center, New York, NY

AAPM SPRING CLINICAL MEETING 2021

Memorial Sloan Kettering Cancer Center

INTRODUCTION

Skin tattoos represent the long-held standard for surface alignment and setup of breast cancer radiotherapy yet contribute to adverse cosmesis and patient dissatisfaction. With the advent of contemporary surface imaging technology, we evaluated setup accuracy, setup time, total in-room time, and dosimetry between "tattoo-less" and traditional tattoo-based setup techniques.

METHOD

Patients receiving accelerated partial breast irradiation (APBI) underwent traditional tattoo-based setup, alternating daily with setup by AlignRT v5.1 (tattooless). Following initial setup, the position was verified by daily kV imaging, with matching on surgical clips to represent ground truth. Translational shifts prompted by kV imaging were ascertained as were setup time and total in-room time. Delivered dosimetry was calculated using the reverse isocenter shift technique. Statistical analysis was performed using Wilcoxon Rank-Sum test.

RESULTS

The first 15 patients were analyzed. The statistics are summarized in Table 1. The mean absolute shifts were 0.30±0.28 cm, 0.24±0.22 cm, and 0.25±0.28 cm for the AlignRT-based setup in vertical, lateral, and longitudinal direction, respectively. The mean absolute shifts using tattoo-based setup were 0.40±0.35 cm, 0.36±0.41 cm, and 0.38±0.29 cm in vertical, lateral, and longitudinal direction, respectively. The corresponding median absolute shifts were 0.24 cm, 0.18 cm, and 0.14 cm for the AlignRT-based setup and 0.30 cm, 0.24 cm, and 0.33 cm for the tattoo-based setup. The mean and median magnitude shifts were 0.56±0.32 cm and 0.50 cm for the AlignRT-based setup and 0.78±0.44 cm and 0.67 cm for the tattoo-based setup, with AlignRT-based setup showing a much narrower distribution (Graph 6). The AlignRT-based setup was at least equivalent to the tattoo-based setup in terms of individual translational shifts and was better than the tattoo-based setup in terms of shift magnitude. Statistically significant difference was found in patient setup time and total in-room time between the two techniques. The mean and median total in-room times were 14.44±6.24 min and 14.00 min for the AlignRT-based setup and 16.25±6.8 min and 15.00 min for the tattoo-based setup. The mean and median setup times were 10.50±10.40 min and 8.15 min for the AlignRT-based setup and 11.45±6.13 min and 10.76 min for the tattoo-based setup. AlignRT-based setup showed a narrower distribution in setup time with fewer lengthy outliers as in the tattoo-based approach (Graph 2). The setup time range for tattoos was 4.08-38.90 min versus 2.62-82.35 min for AlignRT.

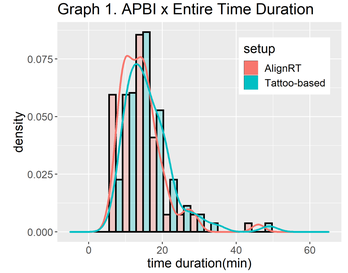
Table 1. Summary of Statistics

	AlignRT (N=73)	Tattoo-based (N=72)	p value
Entire time duration in clinic (min)			0.035
- Mean (SD)	14.44 (6.24)	16.25 (6.80)	
- Median (Q1, Q3)	14.00 (10.00, 16.00)	15.00 (11.00, 19.00)	
- Min - Max	6.00 - 46.00	7.00 - 49.00	
Setup duration in clinic (min)			0.018
- Mean (SD)	10.50 (10.40)	11.45 (6.13)	
- Median (Q1, Q3)	8.15 (5.18, 11.58)	10.76 (6.99, 13.48)	
- Min - Max	2.62 - 82.35	4.08 - 38.90	
VRT axis shift (cm)			
- Mean (SD)	-0.20 (0.36)	-0.25 (0.47)	
- Median (Q1, Q3)	-0.16 (-0.36, 0.00)	-0.19 (-0.54, 0.00)	
- Min - Max	-1.26 - 0.77	-1.29 - 1.41	
LAT axis shift (cm)			
- Mean (SD)	-0.08 (0.31)	-0.02 (0.55)	
- Median (Q1, Q3)	-0.02 (-0.24, 0.15)	-0.10 (-0.30, 0.14)	
- Min - Max	-0.79 - 0.44	-1.36 - 2.29	
LNG axis shift (cm)			
- Mean (SD)	-0.10 (0.37)	0.03 (0.48)	
- Median (Q1, Q3)	-0.02 (-0.26, 0.10)	0.04 (-0.21, 0.41)	
- Min - Max	-1.06 - 1.05	-1.06 - 1.34	
Absolute VRT axis shift (cm)			0.133
- Mean (SD)	0.30 (0.28)	0.40 (0.35)	
- Median (Q1, Q3)	0.24 (0.10, 0.44)	0.30 (0.12, 0.57)	
- Min - Max	0.00 - 1.26	0.00 - 1.41	
Absolute LAT axis shift (cm)			0.051
- Mean (SD)	0.24 (0.22)	0.36 (0.41)	
- Median (Q1, Q3)	0.18 (0.07, 0.34)	0.24 (0.12, 0.44)	
- Min - Max	0.00 - 0.79	0.00 - 2.29	
Absolute LNG axis shift (cm)			0.002
- Mean (SD)	0.25 (0.28)	0.38 (0.29)	
- Median (Q1, Q3)	0.14 (0.06, 0.36)	0.33 (0.14, 0.53)	
- Min - Max	0.00 - 1.06	0.00 - 1.34	
Magnitude shift (cm)			0.003
- Mean (SD)	0.56 (0.32)	0.78 (0.44)	
- Median (Q1, Q3)	0.50 (0.33, 0.78)	0.67 (0.44, 1.05)	
- Min - Max	0.00 - 1.43	0.16 - 2.34	

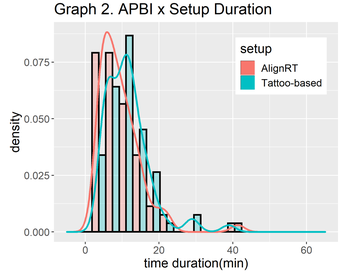
Partial Breast Irradiation		Original Plan	AlignRT	Tattoo-based	Original Plan vs. AlignRT
Structures					
PTV (%)					
	DVH	98.21 ± 0.33	97.73 ± 1.18	97.55 ± 1.18	0.269
	D_{max}	111.22 ± 2.88	112.81 ± 4.69	113.11 ± 4.71	0.271
TumorBed (%)					
	$V_{100\%}$	99.93 ± 0.16	99.33 ± 2.05	99.41 ± 2.05	0.377
Uninvolved Ipsilateral Breast (%)					
	V_{20Gy}	30.72 ± 6.99	30.86 ± 6.74	31.13 ± 6.77	0.735
Ipsilateral Lung (%)					
	V_{20Gy}	1.65 ± 0.99	1.95 ± 1.23	2.02 ± 1.18	0.109
	V_{10Gy}	4.09 ± 2.68	4.45 ± 2.79	4.41 ± 2.73	0.097
	V_{5Gy}	12.23 ± 6.95	12.83 ± 6.92	11.99 ± 6.89	0.049
Contralateral Lung (%)					
	V_{20Gy}	0 ± 0	0 ± 0	0 ± 0	N/A
	V_{10Gy}	0 ± 0	0 ± 0	0 ± 0	N/A
	V_{5Gy}	0 ± 0	0 ± 0	0 ± 0	N/A
Heart (cGy)					
	D_{max}	987.9 ± 1109.3	1265.7 ± 1551.1	1141.6 ± 1550.7	0.201
	D_{mean}	50.5 ± 50.0	55.0 ± 50.5	75.0 ± 50.5	0.291

Abbreviations: N/A, not available

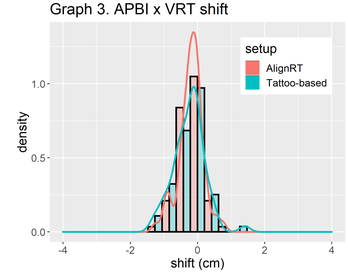
Graph 1. APBI x Entire Time Duration



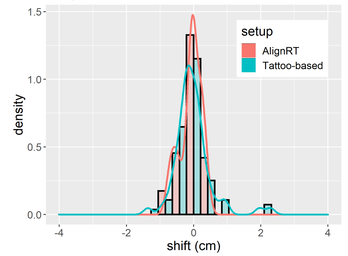
Graph 2. APBI x Setup Duration



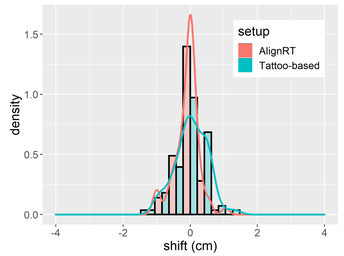
Graph 3. APBI x VRT shift



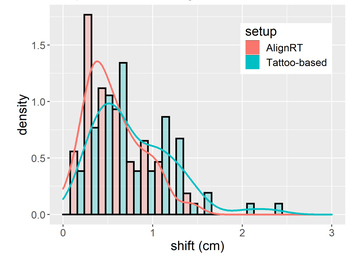
Graph 4. APBI x LAT shift



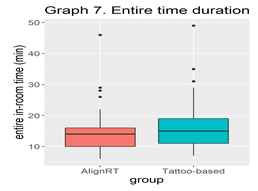
Graph 5. APBI x LNG shift



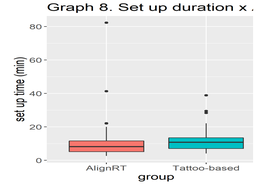
Graph 6. APBI x Magnitude



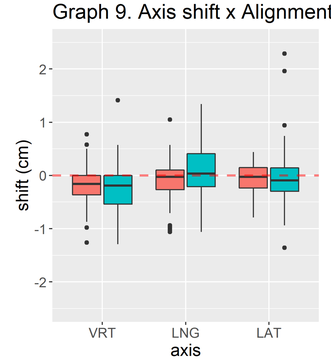
Graph 7. Entire time duration



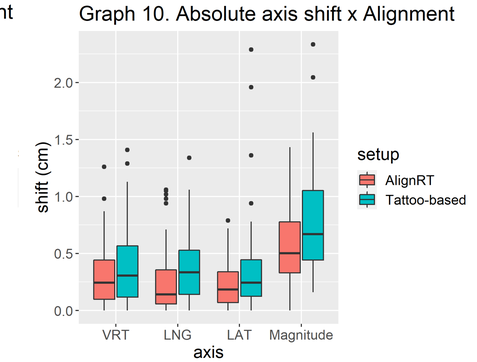
Graph 8. Set up duration x .



Graph 9. Axis shift x Alignment



Graph 10. Absolute axis shift x Alignment



CONCLUSION

These results suggest that a tattooless setup approach to breast radiotherapy with AlignRT may be sufficiently accurate to obviate the need for surface tattoos. Further analyses among large cohorts and including all six degrees of freedom (three translational dimensions along with pitch, roll, and yaw) will determine whether tattoo-based approaches can be replaced by surface imaging.

ACKNOWLEDGEMENTS

This research was funded in part by the NIH/NCI Cancer Center Support Grant P30 CA008748, The Lois Green Fund, and The Rose-Margulies Family Research Fund.