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Impact of combining advanced dynamic collimator arc therapy with flattening filter-free beams on plan quality and delivery efficiency in postmastectomy radiotherapy

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INTRODUCTION AND PURPOSE

- **Treatment planning for postmastectomy radiotherapy (PMRT)** is challenging due to the large and complex target volumes adjacent to critical organs, resulting in an increased number of required arcs.
- **RapidArc Dynamic (RAD)**, incorporating dynamic collimator rotation and static angle modulated ports (STAMPs) in a single continuous delivery, has the potential to improve plan quality and delivery time, with reported usefulness in node-positive breast cancer.[1, 2]
- The use of **flattening filter–free (FFF) beams** in PMRT further reduces delivery time through higher dose rates[3], but no studies have reported combining RAD with FFF beams.
- The purpose of this study was to evaluate the dosimetric impact and delivery efficiency of **combining RAD with FFF beams** in PMRT.

METHODS AND MATERIALS

- Twenty-four patients (12 left-sided and 12 right-sided) who underwent mastectomy were retrospectively analyzed.
- The target volume included the chest wall (CW), supraclavicular lymph nodes (SC), and internal mammary lymph nodes (IM) in all patients.
- Two RAD plans (6 MV: **RAD_6X**, 6 MV FFF: **RAD_6F**) were generated in Eclipse version 18.1 for TrueBeam and compared with a conventional VMAT plan (6 MV: **VMAT_6X**) using four split arcs.
- All plans were prescribed **50 Gy in 25 fractions** and were normalized to $D_{50\%}$ of the PTV_CWSC, the combined PTV_CW and PTV_SC cropped 3 mm from the skin surface.
- All plans were generated in a single optimization process using **a RapidPlan model** trained on 42 conventional VMAT plans, along with **the virtual bolus technique**.
- We evaluated $D_{2\%}$ and $D_{95\%}$ of PTV_CWSC and CTV_IM, mean doses to the heart, contralateral breast, and lungs, total monitor units (MUs), and delivery time using Bonferroni-corrected paired t-tests.

Table 1. Beam delivery and planning parameters for the RAD plans.

Parameters	Left-sided patients	Right-sided patients
Number of Arc	1	
Arc Span [°]	300-120 (CW)	60-240 (CCW)
Arc Avoidance	N/A	
Isocenter position	The Arc Geometry Tool was applied to PTV_total.	
STAMP angles [°]	①300, ②350, ③120	①240, ②10, ③60
STAMP Weighting	Balanced (0)	
Collimator angles [°]	①15, ②60, ③165	①195, ②300, ③345
Collimator Rotation	Optimize between static angles	
Aperture	• The X-jaw was set asymmetrically to fully cover PTV_CW at the tangential STAMP angles and PTV_SC at the anterior STAMP angle. • The Y-jaw was set to a range that fully covered all PTVs.	
Iterations	4000	
Automatic Skin Flash	N/A	

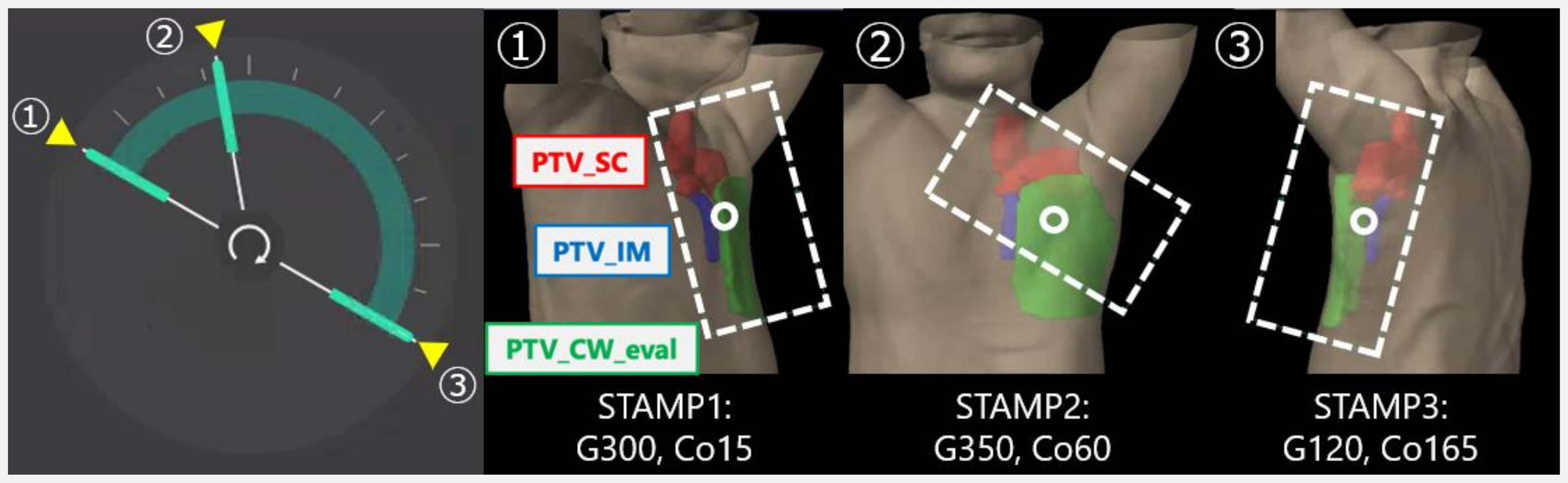

Figure 1. Beam arrangement for both RAD plans in a representative case of left-sided PMRT. For the three static angle modulated ports (STAMPs), the gantry angle is indicated by G, and the collimator angle by Co.

RESULTS

- PTV $D_{2\%}$ showed no significant differences, whereas **RAD plans significantly improved target coverage ($D_{95\%}$) and OAR sparing**, with mean differences from VMAT_6X of **approximately 1% and −10% to −20%, respectively**.
- RAD_6F further improved target coverage and OAR sparing compared with RAD_6X, except for $D_{2\%}$ and $D_{95\%}$ in CTV_IM.
- Total MU required was greatest for RAD_6F, followed by RAD_6X and VMAT_6X, while delivery time showed the opposite trend. **RAD_6F reduced delivery time by 41.7%** relative to VMAT_6X, substantially exceeding the 13.7% reduction achieved by RAD_6X.
- Comparison of the isodose distributions showed that both RAD plans reduced the 5-Gy isodose volume in the heart, contralateral breast, and lungs to a greater extent than VMAT_6X (Figure 2.).

Table 2. Comparison of dosimetric metrics and delivery metrics of the VMAT plan and the two RAD plans.

Metric		Mean value ± standard deviation			p value		
		VMAT_6X (A)	RAD_6X (B)	RAD_6F (C)	A vs. B	A vs. C	B vs. C
PTV_CWSC	$D_{2\%}$ [%]	103.5 ± 0.36	103.4 ± 0.46	103.5 ± 0.50	0.368	0.414	0.466
	$D_{95\%}$ [%]	94.7 ± 0.62	95.7 ± 0.75	95.9 ± 0.72	< 0.001*	< 0.001*	< 0.001*
CTV_IM	$D_{2\%}$ [%]	103.6 ± 0.92	102.4 ± 0.64	102.5 ± 0.76	< 0.001*	< 0.001*	0.513
	$D_{95\%}$ [%]	94.6 ± 0.86	95.4 ± 1.12	95.5 ± 1.16	< 0.001*	0.011*	0.049
Heart	D_{mean} [Gy]	3.20 ± 1.04	2.85 ± 1.06	2.80 ± 1.07	< 0.001*	< 0.001*	< 0.001*
Contralateral breast	D_{mean} [Gy]	5.00 ± 0.49	4.13 ± 0.75	4.01 ± 0.75	< 0.001*	< 0.001*	< 0.001*
Lungs	D_{mean} [Gy]	7.41 ± 0.74	6.64 ± 0.76	6.55 ± 0.77	< 0.001*	< 0.001*	< 0.001*
Total MUs [MU]		504 ± 100	645 ± 58	786 ± 81	< 0.001*	< 0.001*	< 0.001*
Delivery time [sec]		80.3 ± 4.95	69.3 ± 6.19	46.8 ± 2.59	< 0.001*	< 0.001*	< 0.001*

* showed $p < 0.017$, adjusted using the Bonferroni correction to the significance level ($p < 0.05$).

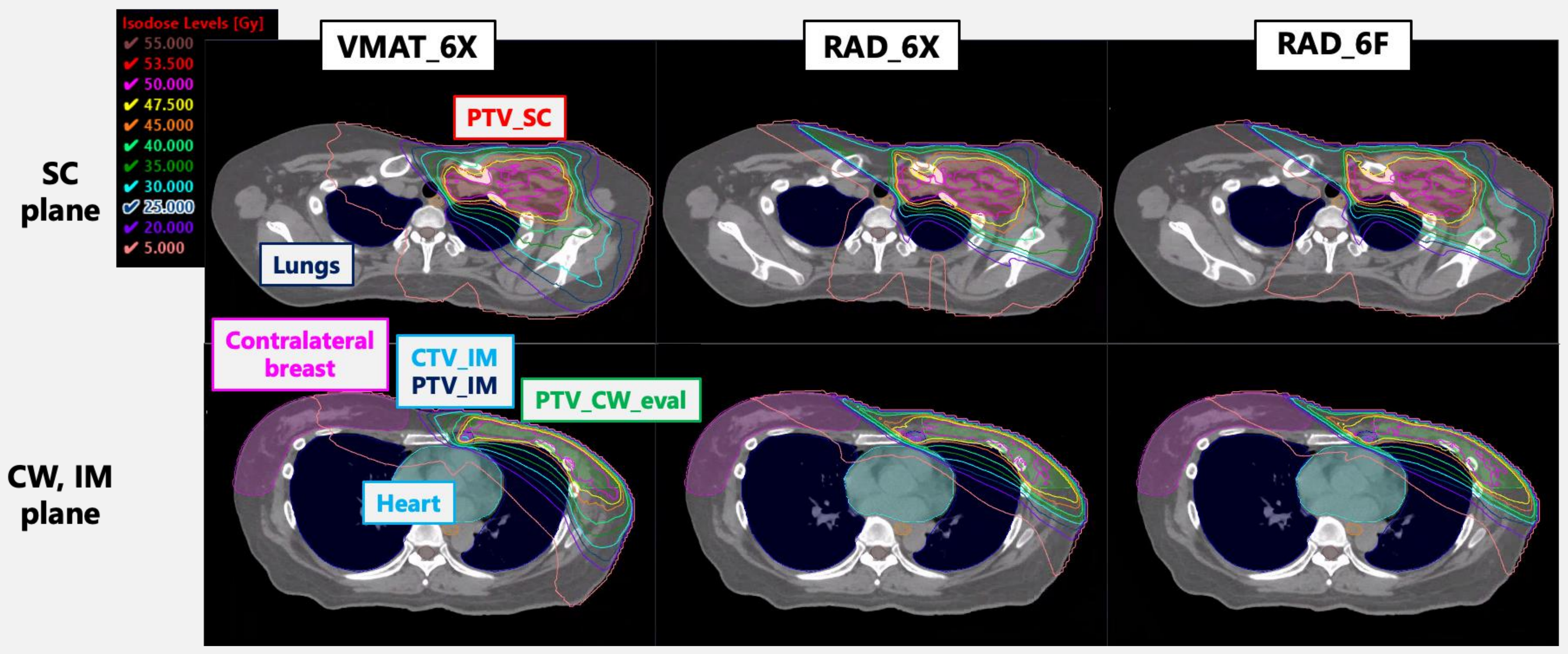

Figure 2. A representative case of left-sided PMRT showing isodose differences on the SC plane, the CW and the IM plane of the VMAT plan and the two RAD plans.

DISCUSSION

- Dosimetric improvement with RAD, as well as MU increases with RAD and FFF beams, were consistent with previous studies.[1-3]
- **The additional benefit with FFF beams** is likely attributable to a synergistic effect between the reduction in out-of-field dose from decreased head scatter[3] and the established benefits of RAD's dynamic collimator rotation.
- **RAD_6F substantially improved delivery time**, which was closely associated not only with the use of FFF beams but also with arc span and the number and weighting of STAMPs.
- **Limitations** include the potential for further optimization of RAD settings, as well as the lack of automatic skin flash evaluation and linac-based patient QA.

CONCLUSIONS

- **Combining RAD with FFF beams significantly improved target coverage and OAR sparing while reducing delivery time compared with conventional multi-arc VMAT.**
- Our findings offer practical guidelines for optimal beam arrangement and parameter settings when implementing RAD with FFF beams in PMRT, **highlighting its potential to reduce treatment-related toxicities and enhance clinical workflow efficiency.**

REFERENCES

1. Rostami et al. RapidArc dynamic versus RapidArc: A multi anatomical-site dosimetric evaluation. J Appl Clin Med Phys 2026; 27: e70404
2. Nykanen et al. Optimization of field setup for organs at risk sparing and beam on time in breast radiotherapy planning for a new volumetric modulated arc therapy-based treatment technique. Phys Imaging Radiat Oncol. 2026; 39: 101016
3. Zhang et al. Flattening filter-free volumetric-modulated arc radiotherapy for left-sided whole-breast, partial-breast, and postmastectomy irradiations. J Med Phys 2022;47:166-72.

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