

TOWARDS MEASURING FEASIBILITY OF ESTABLISHING INSTITUTIONAL PTV MARGIN FOR 3D AND VMAT BREAST RADIOTHERAPY USING LOCAL IGRT SETUP ANALYSIS

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INTRODUCTION

The Planning Target Volume (PTV) margin is a geometric expansion designed to compensate for systematic setup uncertainties and internal motion during treatment. This study evaluates the feasibility of establishing institutional PTV margins from local data workflows, immobilization and positioning techniques as well as image-guided radiotherapy (IGRT) protocols. This reflects the planned dose distribution and supports dose accuracy while minimizing radiation exposure to critical organs at risk (OAR) in breast cancer patients.

METHODOLOGY

A retrospective analysis of translational shift data was conducted for 159 breast cancer patients treated with radical intent in 2025. Treatment techniques included 3D-Conformal Radiotherapy (3D-CRT) and Volumetric Modulated Arc Therapy (VMAT). Daily setup deviations in the lateral (x), longitudinal (y) and vertical (z) planes were extracted from the Mosaik Oncology Information System and analyzed. The PTV margin (M) was calculated using the commonly adopted margin recipe Van Herk formula, $M=2.5\Sigma+0.7\sigma$.

RESULTS & DISCUSSION

The calculated Van Herk margins of 4.7 mm for 3D-CRT and 4.9 mm for VMAT prove that patient setup at simulation is highly reproducible and technique-independent. Since both cohorts shared identical immobilization workflows, breast boards, and daily image-guided radiotherapy (IGRT) protocols, the underlying systematic (Σ) and random (σ) errors remain constant. As the values fall safely within standard limits, we recommend reducing and standardizing the institutional PTV margin to 5 mm for both techniques. This reduction aligns with advanced frameworks such as the FAST-Forward trial, shifting away from historical 10 mm legacy margins to optimize healthy tissue sparing. However, standard 3D-CRT utilizes open tangential fields with fixed geometric boundaries, creating a forgiving, "box-like" dose distribution less sensitive to minor anatomical changes. Conversely, inverse-planned VMAT sculpts highly conformal dose clouds tightly bound to the target volume. While this volumetric precision maximizes OAR sparing, it leaves VMAT target coverage more vulnerable to daily tissue swelling or contour variations. Therefore, while a uniform 5 mm margin is fully justified by our local workflow errors, maintaining optimal dose accuracy requires stricter adherence to volume and contour consistency when utilizing VMAT.

Tx_Intent	Category	Diagnosis	Rx_Site	Acquire Date	Fx	X	Y	Z
1_Curative	Thorax	Female breast, NOS (excludes skin of breast t-173.5)	LT BREAST	30/6/2025 14:56	1	-0.4	1.8	1
1_Curative	Thorax	Female breast, NOS (excludes skin of breast t-173.5)	LT BREAST	1/7/2025 8:21	2	-0.5	0	0
1_Curative	Thorax	Female breast, NOS (excludes skin of breast t-173.5)	LT BREAST	2/7/2025 8:23	3	-0.3	0.1	-0.1
1_Curative	Thorax	Female breast, NOS (excludes skin of breast t-173.5)	LT BREAST	3/7/2025 8:32	4	0	0.4	0.4
1_Curative	Thorax	Female breast, NOS (excludes skin of breast t-173.5)	LT BREAST	4/7/2025 8:33	5	0	0.1	-0.1
1_Curative	Thorax	Female breast, NOS (excludes skin of breast t-173.5)	LT BREAST	8/7/2025 8:22	6	0.3	0.4	0.3
1_Curative	Thorax	Female breast, NOS (excludes skin of breast t-173.5)	LT BREAST	8/7/2025 11:03	6	0	0.1	0.4
1_Curative	Thorax	Female breast, NOS (excludes skin of breast t-173.5)	LT BREAST	9/7/2025 8:21	7	0.5	0.3	0.4
1_Curative	Thorax	Female breast, NOS (excludes skin of breast t-173.5)	LT BREAST	10/7/2025 8:25	8	0.4	0.3	0.9
1_Curative	Thorax	Female breast, NOS (excludes skin of breast t-173.5)	LT BREAST	11/7/2025 8:26	9	0.2	0.6	1.1

Figure 1: Daily setup deviations extracted from MOSAIQ OIS

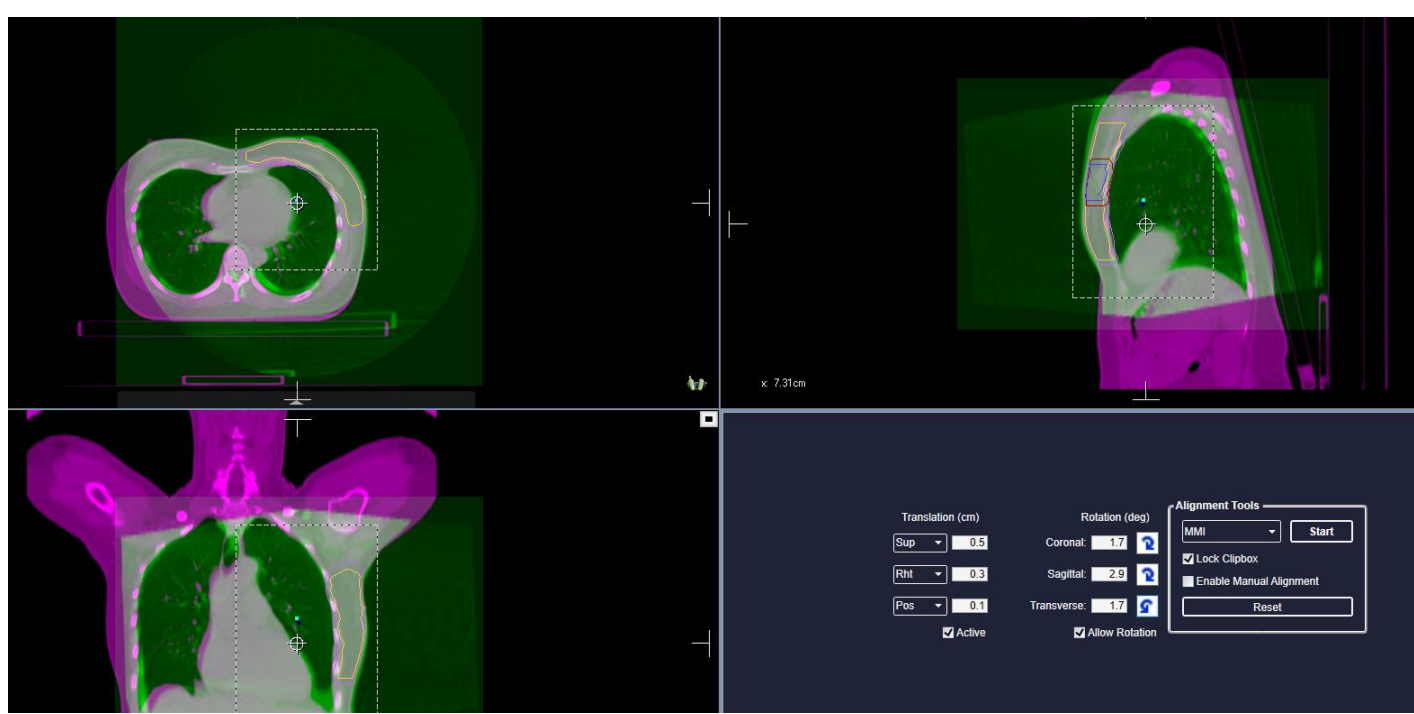


Figure 2: Daily IGRT alignment for left breast VMAT; green represents CBCT images, purple represents simulation references images

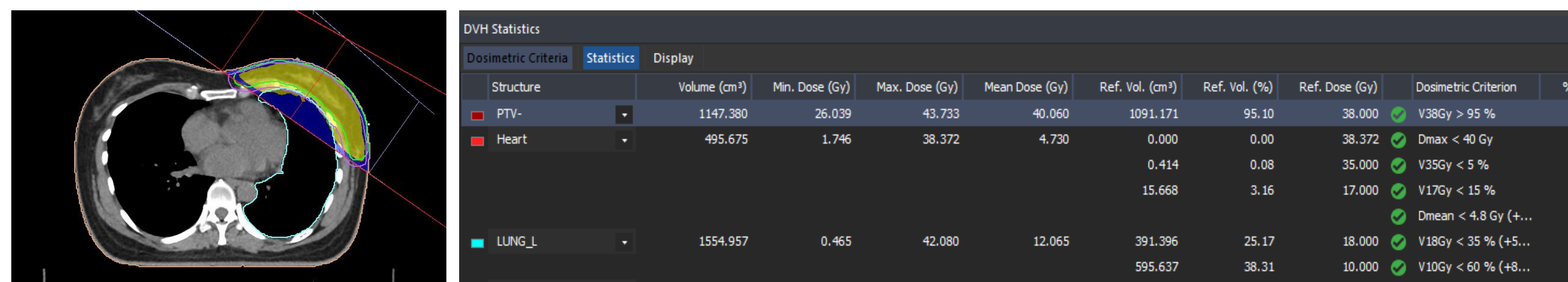


Figure 3(a): 3D-CRT planning with PTV (purple) expansion of 5mm from CTV (red); 3(b): Corresponding DVH statistics for 3D-CRT planning

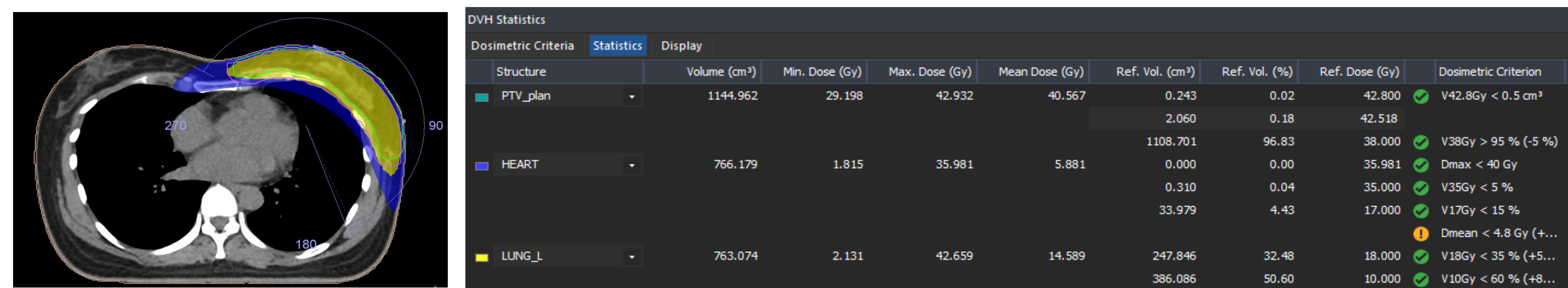


Figure 4(a): VMAT planning with PTV (purple) expansion of 5mm from CTV (red); 4(b) Corresponding DVH statistics for VMAT planning

CONCLUSION

The study confirms the feasibility of a 5 mm institutional PTV margin in breast radiotherapy for 3D-CRT and VMAT treatments. Implementing evidence-based PTV margins further ensure institutional accuracy of planned dose distributions and thus reduce organs at risk doses by avoiding excessive volumetric expansions, thereby offering a better treatment outcome for patients.

REFERENCES

Mcnair, Helen & Franks, Kevin & Herk, M.. (2021). On Target 2: Updated Guidance for Image-guided Radiotherapy. Clinical Oncology. 34. 10.1016/j.clon.2021.10.002.