ONCODAILY MEDICAL JOURNAL

abstract

# Machine Learning Model adopting In-vivo dosimetry as a surrogate QA tool for predicting setup reproducibility and residual shifts in right-sided breast radiotherapy

**Ali Eid, Mahmoud Ahmed, Ramanathan Viswnathan, Zainab Alhaddad**

DOI: 10.69690/ODMJ-018-3101-6612

AMSTRO
Asia and Middle East Society of Therapeutic Radiation and Oncology
Affiliated with ASTF

*abstract*

# Machine Learning Model adopting In-vivo dosimetry as a surrogate QA tool for predicting setup reproducibility and residual shifts in right-sided breast radiotherapy

**Author: Ali Eid[1], Mahmoud Ahmed[1], Ramanathan Viswnathan[1], Zainab Alhaddad[1]**

**Affiliation: [1]Bahrain Oncology Centre, Manama, Bahrain**

**DOI: 10.69690/ODMJ-018-3101-6612**

**Introduction:** To evaluate whether daily in vivo dosimetry can work as a predictive QA surrogate for residual setup errors and dosimetric reproducibility in right-sided breast radiotherapy. The study evaluates correlations between ΔIn-Vivo dose variations, CBCT-based residual shifts, and align-rt SGRT-based residual shifts and explores a machine-learning model for predicting clinically relevant deviations.

**Methodology:** Sixty right-sided breast cancer patients treated with VMAT (2 partial arcs) with free breathing were prospectively classified into three setup-verification arms (n=20 each): Arm 1: Pre/post CBCT with SGRT monitoring. Arm 2: Same approach with SGRT beam-hold (>3 mm / 2°). Arm 3: Pre/post CBCT + SGRT beam-hold with intra-fraction correction between VMAT partial arcs. Nanodot in vivo dosimetry for all patients and all fractions was placed on medial and lateral points. The first fraction is set as the reference baseline (ΔIn-Vivo = 0) to calculate ΔIn-Vivo/fraction, using identical NanoDots to remove intra-dosimeter variability. Translational and rotational shifts were extracted from CBCT (ΔCBCT) and mean deviations from AlignRT logs. Correlations were quantified using SPSS (Shapiro-Wilk, ANOVA, Bonferroni). A predictive model was developed using MATLAB regression and classifier learners.

**Results:** All datasets showed normal distribution (Shapiro–Wilk $p > 0.05$). One-way ANOVA revealed significant differences across arms for geometric accuracy and ΔIn-Vivo values ($p < 0.01$). With Residual Shifts (mean ± SD): Arm 1: 1.9 ± 0.8 mm, 1.0 ± 0.4°; Arm 2: 1.1 ± 0.5 mm, 0.7 ± 0.3°; and Arm 3: 0.7 ± 0.2 mm, 0.5 ± 0.2° ($p < 0.001$). Mean Δ In-Vivo from baseline was Arm 1: 5.8% ± 3.1%, Arm 2: 3.1% ± 1.9% And Arm 3: 1.6% ± 1.1%. 10–20% deviations of in vivo doses occurred in patients with large breasts or anatomical curvature. Machine-Learning Performance: Regression learner (Gaussian process algorithm): RMSE 2.2%, $R^2 = 0.82$, Classifier (Support Vector Machine): Accuracy 83%, RMSE 2.1%. Arm 3 achieved the highest geometric precision and lowest Δ in vivo variability, showing the benefit of intrafraction

correction.

**Conclusion:** There is a strong correlation of in vivo dosimetry with geometric residual shifts, and it can serve as a daily practical surrogate QA indicator for setup reproducibility. Accuracy can be significantly enhanced by SGRT beam control with intra-fraction correction. The ML model shows predictive capability for real-time detection of setup deviations to be further improved by anatomical correlations.

**Conflict of interests:** The authors declare no conflict of interests.

**Funding:** This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.