ABSTRACT

KU LEUVEN

In Silico Patient-Specific Quality Assurance for RapidArc Dynamic Breast Treatments

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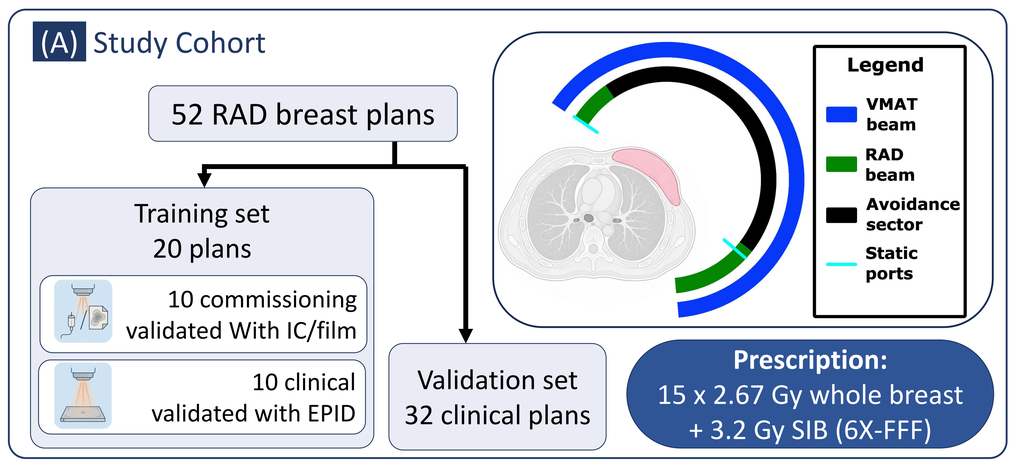
PURPOSE

In **Adaptive Radiotherapy** (**ART**) workflows, measurement-based PSQA is often impractical. This creates a need for **in silico QA** to assess plan deliverability.

- **Tumor-site-specific class solutions [1]** enable targeted **complexity metric**-based [2] thresholds because beam characteristics are consistent across plans.
- **Beam-level complexity thresholds** allow for more targeted QA [3].

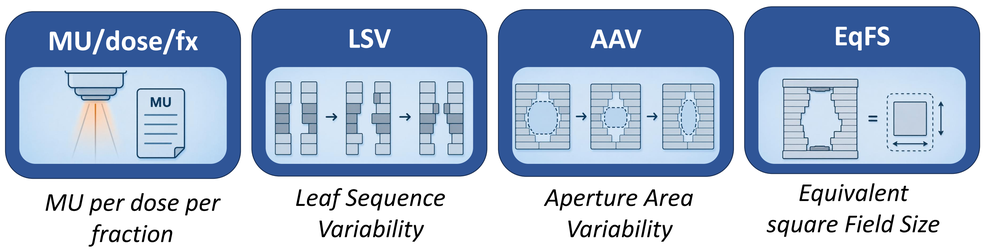
AIM: Beam-level analysis of complexity metric variation within a RapidArc Dynamic (RAD) breast class solution

METHODS AND MATERIALS



(B) Statistical Process Control (SPC, [4]) threshold development

Robust control limits (CLs) derived per beam from the training set for four complexity metrics:



$$CLs = median \pm 3 \cdot \sigma$$
$$\sigma = 1.4826 \cdot MAD$$

(C) Outlier detection using SPC limits

Evaluate each validation plan **using 8 checks** (4 metrics x 2 beams)

Compare each metric to expected variation / SPC limits

≥ 6/8 within SPC limits
→ **Plan within expected variation**

< 6/8 within SPC limits
→ **Plan classified as outlier**

RESULTS

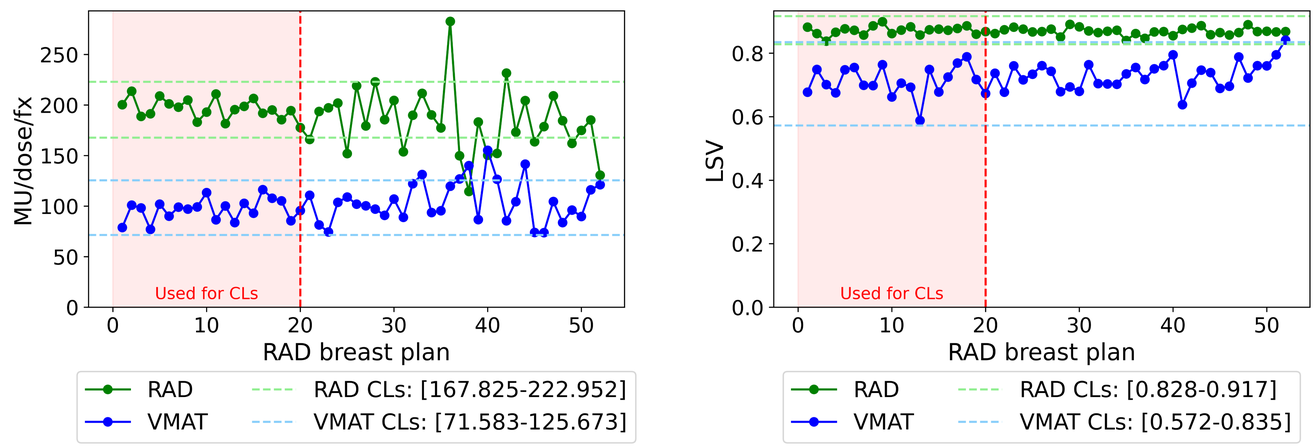


Figure 1: Datapoints and control limit (CLs) for the calculated MU/dose/fx, LSV, AAV, and EqFS metrics for both RAD and VMAT beams. CLs were calculated using the first 20 RAD breast plans. Note: These 20 training plans were created by the same two planners, resulting in highly stable metric values for the training set.

- Expected variations were narrow and beam-specific. → This supports beam-level complexity analysis.
- In the validation cohort, 93.8% of plans met the ≥ 6/8 metric criterion.

CONCLUSIONS

- This study gives a first characterization of established complexity metrics applied to RAD beams.
- Beam-specific, complexity-based SPC limits captured systematic differences between RAD and VMAT beams in a RAD breast class solution, enabling narrow, targeted, beam-level QA thresholds for class solution compliance.

FUTURE WORK

- Explore multivariate thresholds to account for the correlation between the metrics.
- Explore sensitivity and specificity of the QA thresholds using plans with introduced perturbations that simulate deviations from the class solutions.
- Explore expected complexity variation in an adaptive setting.

REFERENCES

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