

Daily dosimetric evaluation of the delivery of high precision breast irradiation using synthetic CTs derived from CBCT images



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Motivation:

In the concomitant treatment of breast and internal mammary nodes (IMNs), the reproducibility of the planning anatomy faces two challenges:

- * Daily deformable change to breast tissue
- * Variation in location of breast relative to IMNs

Goal /Innovation:

Our goal was to evaluate doses delivered with Volumetric modulated arc therapy (VMAT) technique for the treatment of the breast and IMNs for several daily alignment strategies. To the best of our knowledge, this is the first study to evaluate doses delivered to combined breast and IMN targets.

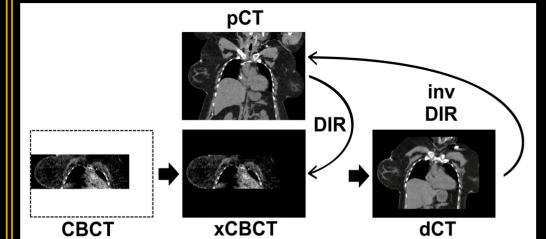


Figure 1 Workflow to create the daily CT (dCT). CBCT is expanded to match the scan extent of the planning CT (pCT) to create an extended CBCT (xCBCT). pCT is deformed to make dCT.

Key Results:

PLANNING:

- IMN_D95 and Breast_D95 planned doses were within acceptable variation from planning directives, IMN_D90 and Breast_D90 usually exceeded planning directives.
- OAR planned doses met or marginally met the planning directives. Hardest constraints to meet were ContraBreast_V3Gy <3%, lpsiLung_V20Gy<15%, ContraBreast_V3Gy<5%.

DELIVERY:

Alignment inaccuracies degraded usually all doses from their planned values and the planning directive values. For **TARGETS**, D90 values remained within the planning directive values, due to more generous planned doses, D90 values degraded further from their planned values, and thus the deviation from the planning directives worsened. **OAR** dose values varied between patients and some OARs received less dose to the detriment of other OARs.

RELATIVE COMPARISONS of the ALIGNMENT STARTEGIES:

Split-target and IMN alignments generated similar cumulative delivered doses and fared best in terms of the dosimetric outcome of the alignment. This may be suggestive of an unconscious bias toward the IMN alignment in the split target approach. Poorest outcome was associated with the breast-only alignment (Figure 4).

Materials and Methods: Several alignment strategies were simulated: split-target (split differences between the alignment of the breast and the IMNs), breast only, IMNs only, rib cage - translations only (Rib T), rib cage - translations and rotations (Rib TR).

- For each alignment strategy we evaluated the differences between:
 - Planned doses and planning directives
 - Delivered doses and planning directives
 - Delivered doses and planned doses
- Doses were analyzed for targets and OARs.
- 5 daily Cone beam CTs (CBCTs) per patient were utilized, for 5 patients (laterality: 3 right, 2 left).
- Delivered dose simulation approach is illustrated in Figures 1 and 2.

					Organ	Metric	Constraint
	Organ	Metric	Constraint	F	Contralateral Breast	V3G _V	5%
Α	Contralateral Breast	V3Gy	10%	G	Contralateral Breast	V5Gy	10%
В	Contralateral Breast	V5Gy	15%	н	Heart	Dmax	25Gy
C	Ipsilateral Lung	V10.0Gy	65%	1	Heart	Dmean	4Gy
D	Ipsilateral Lung	V20.0Gy	15%	J	Ipsilateral Lung	V10.0Gy	50%
E	Ipsilateral Lung	V5.0 Gv	75%	K	Ipsilateral Lung	V20.0Gy	30%
_				L	Ipsilateral Lung	V5.0 Gy	65%

Figure 3 Patients were planned using either B51 (A-E) or Henrietta (F-L) protocol planning directives.

Conclusion:

The highly conformal VMAT plans are overall sensitive to the challenges posed by the non-rigid nature of the variations in the daily anatomy. The split-difference and the IMN alignment strategies are most effective for the dosimetric outcome. IMN alignment is likely more consistent and quicker to complete. There is a large variability among patients and the patient dose delivery QA methodology presented here will help identify challenging patient setups that may require treatment adaptation.

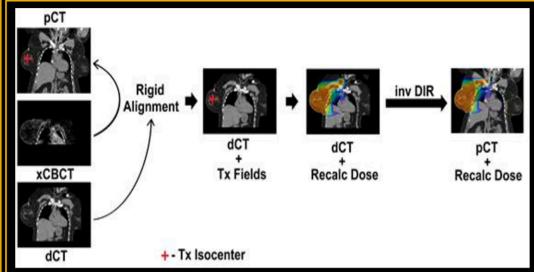


Figure 2 CBCT was rigidly aligned to pCT in several ways. The treatment fields (isocenter denoted by red crosshairs) were transferred to dCT using the rigid alignment. Dose was recalculated and transferred to the pCT for evaluation purposes.

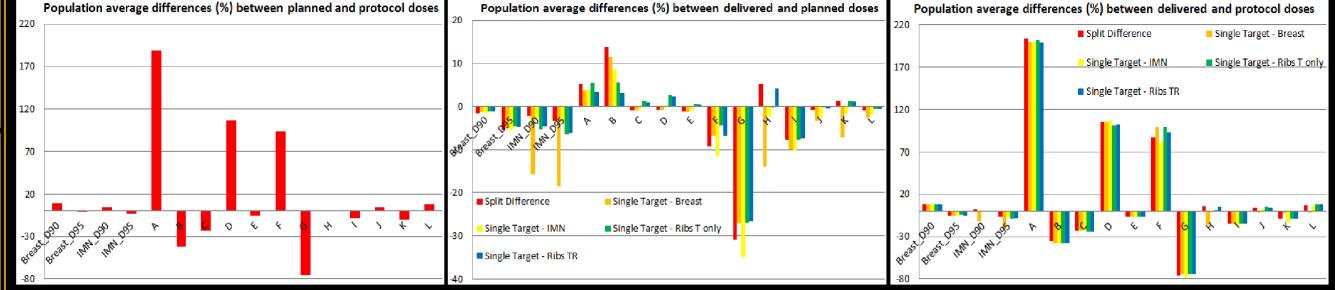


Figure 4 Average differences for the population considered of the differences in doses for the scenarios investigated. The letters A-L are corresponded to the planning constraints of Figure 3.