model, irrespective of dose metrics, to make direct comparisons between different symptoms feasible.

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PO-0906 Robust breast VMAT plan optimisation accounting for breast swelling and positional changes

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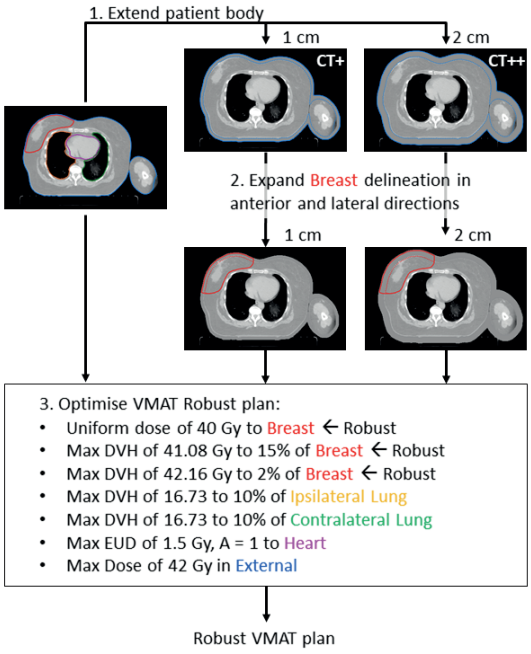
Purpose or Objective

Treatments using full IMRT and VMAT are gaining acceptability in difficult breast cancer cases. However, common changes in the breast tissue, such as swelling and breast positional changes, still pose a challenge to plan optimisation, and lead to a large amount of adaptive re-plans in clinical practice. We investigated the feasibility of a simple and pragmatic strategy to enable optimization of robust breast VMAT plans.

Material and Methods

Data from two recently treated breast cancer patients (1 right-, 1 left-sided) were used. Figure 1 summarizes the method. To simulate swelling and account for breast positional changes, the planning CT was altered by filling a ring of 1 and 2 cm thickness around the patient's body with fat-equivalent HU, referred to as *CT+* and *CT++* from now on. Breast contours, delineated according to ESTRO guidelines 1.1, were copied to CT+ and CT++ and subsequently expanded by 1 or 2 cm in the anterior and lateral direction; creating a multiple instance geometry. VMAT plans, 40 Gy in 15 fractions, with a partial arc were optimised with RayStation 5.99, using the objectives shown in figure 1. All objectives related to breast contours were set to be robust evaluating the planning CT, CT+ and CT++. A non-robust plan was also generated using the planning CT only. Plans were optimised until they were considered optimal by the algorithm (tolerance 10^{-5}). The robust and non-robust plans were evaluated in CT+ and CT++. DVH curves are reported.

Figure 1: Schematic of the proposed methodology.

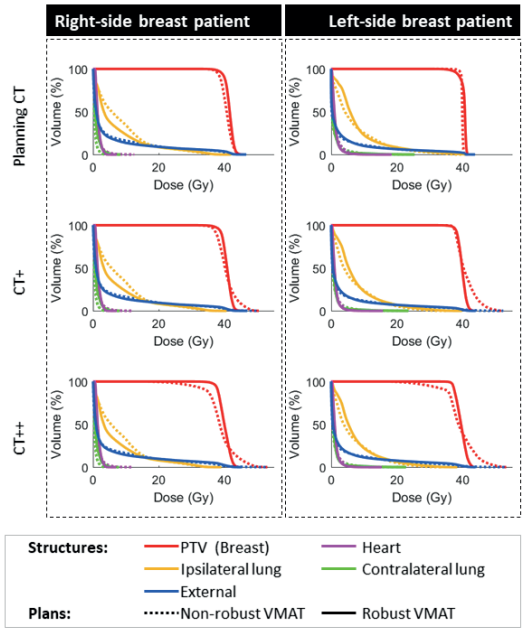


Results

Figure 2 shows the DVH curves for both plans evaluated on all CTs. Both robust and non-robust plans offered similar target coverage (mean dose ~40Gy) and ipsilateral lung sparing ($D_{10\%}$ ~ 18Gy), while larger differences were seen for the heart ($-2.6 \leq \Delta V_{5\%} \leq 4.2\%$, where Δ = robust minus non-robust) and contralateral lung ($-2.1 \leq \Delta V_{5\%} \leq 11\%$).

When evaluated in CT+ and CT++, PTV coverage deteriorated for non-robust plans adding hot and cold spots ($3.9 \leq \Delta D_{1\%} \leq 10.4$Gy and $-16 \leq \Delta D_{99\%} \leq -1.3$Gy, where Δ is DVH value at CT+ or CT++ minus DVH value at planning CT). Robust plans were relatively stable: $-0.7 \leq \Delta D_{1\%} \leq 1.4$Gy and $-1.8 \leq \Delta D_{99\%} \leq 0.6$Gy. Doses to OARs remained relatively the same.

Figure 2: DVHs for VMAT plans for the right-sided and left-sided breast patients evaluated in CT+ and CT++. Notice how PTV coverage deteriorates for non-robust VMAT plans.



Conclusion

This simple and pragmatic procedure, based on artificially expanding the planning CT and a commercial implementation of robust planning, enables optimisation of VMAT plans for breast cancer patients accounting for swelling and positional changes of up to 2cm. This methodology can be seen as an alternative to manually expanding the collimator leaves to create a 'flash' or overshoot region (which is impractical in VMAT or full IMRT) and could also be used in inverse optimisation of IMRT plans. Moreover, creating a robust plan in this way could potentially reduce the number of re-plans. We are currently validating this approach for more challenging cases such as pectus excavatum, partial breast and cases where PTV includes the internal mammary chain, axillary and supraclavicular nodes.

PO-0907 Fast, automatic and robust dose restoration for online IMPT adaptation.

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Purpose or Objective

Intensity-modulated proton therapy (IMPT) offers excellent dose conformity and healthy tissue/OAR sparing, but it can be substantially compromised in presence of anatomical changes. A major dosimetric effect is caused by density changes, which alter the planned proton range in patient. We present two methods which automatically restore an IMPT plan dose on a CT image and can be easily implemented in commercial treatment planning software.

Material and Methods

First, we implemented an automatic (and robust) approach iDR (iso-volume Dose Restoration), which adapts the energy of each pencil beam to the new anatomy and re-optimizes the dose distribution using a set of iso-dose volumes generated from the initial, clinically-approved plan. Iso-dose volumes were generated every 2Gy dose increments within 95-107% of the prescription dose. A 5Gy increment was used otherwise. Second, iDR was compared to a simple dose restoration (DR), where the dose-volume objectives of the initial plan are used in the re-optimization step. iDR and DR were tested on three clinical cases, selected to test on large density change, complex dose distribution and robust re-optimization. IMPT plans were optimized in RayStation 6. CTV-robust optimization was used for lung planning (and restoration) and a clinically relevant PTV margin for oropharyngeal and nasopharyngeal cases. Repeated CTs (rCT) were aligned with planning CTs (pCT) using rigid registration focusing on bony anatomy, which was later used to propagate the planning volumes on rCT.

Results

All dose restorations were obtained in <5min (including 4d robust lung case), without manual adjustments of optimization settings. Evaluations on the repeated CTs showed large dose distortions, which were substantially reduced after restoration (fig. 1). In general, both DR and iDR substantially improved DVH-based scores in propagated target volumes and OARs. Analysis of local dose differences shown that, although both DR and iDR performed similarly in high dose regions, the iDR restored initial dose with higher precision and accuracy in whole patient anatomy (fig. 2).

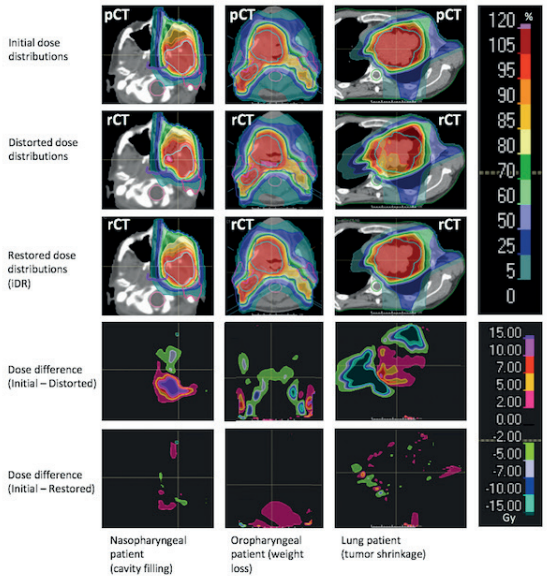

Fig.1. Dose distortions are substantially reduced with dose
restoration.

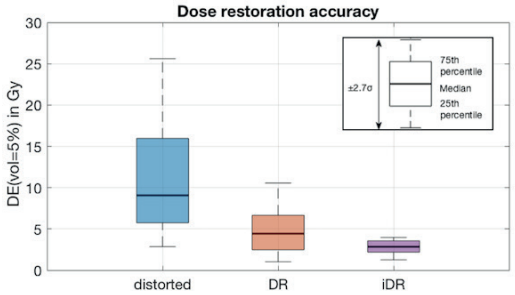

Fig.2. Dose restoration accuracy for all evaluations on repeated CTs.