performed. Table 1 summarizes the results obtained in terms of: number of CBCT acquired (#CBCT), number of CBCT/TPCT registrations (#REG) and threshold below which the agreement between the observers was 90% and 95% (Threshold_mm95% and Threshold_mm90%). The prostate patient had the largest threshold values, but always inferior to the planning target (PTV) margin and only 4% of the 713 differences evaluated were above the 5 mm or 7mm PTV margins used in the clinical routine for the respective VMAT treatment paradigms.

Table 1

			Threshold_mm 95%			Threshold_mm 90%		
	#CBCT	#REG	AP mm	LL mm	CC mm	AP mm	LL mm	CC mm
Head&Neck	30	480	1.7	1.1	1.1	1	1	1
Lung	30	480	1.8	1.1	2	0.9	1.1	1.4
Prostate	39	713	4.2	5.4	2.8	3.2	2.5	1.5
Breast	12	192	1	2	2	0.9	1.6	1.1
Gastric	26	416	1.8	2	2.3	1	1.1	2

Conclusion

Interobserver reproducibility between trained RTs and an expert radiation oncologist was very good. The largest variability was observed for prostate, probably as a consequence of the more difficult interpretation of the CBCT/TPCT fusion. The study will be extended to a larger number of patients and Radiation Oncologists to validate the results and provide a robust basis for the definition of IGRT protocols.

EP-1985 Clinical feasibility of CBCT-based online plan adaptation for multiple lesion brain SRS

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Purpose or Objective

In the absence of a 6DoF couch, IGRT can correct for translation but is not able to manage more complex anatomical changes, including rotations. This study aims to develop and evaluate an online method to automatically adapt treatment plans to the anatomy of the day. As a first showcase, we apply the method to multiple lesion brain SRS.

Material and Methods

All plans in this study are made with a GTV-PTV margin of 2 mm and a single isocentre, an approach we apply if the targets are < 4 cm apart.

The plan adaptation consists of 5 automated steps. 1) The CBCT is rigidly registered to the planning CT. A new CT, that represents the anatomy of the day, is created by applying the registration results to the original planning CT. 2) The treatment plan is transferred to the new CT in our TPS Pinnacle[3]. 3) A custom built script, based on Ahunbay et al. (2008), morphs the segment apertures to the new targets. 4) A segment weight optimization (SWO) is performed. 5) The plan is exported and checked. The method was evaluated by applying it 55 times (11 setup errors for 5 patients). 10 errors were randomly sampled from the typical setup error for this patient group ($\sigma_{tx,ty,tz}$=1.3mm, 1.6mm, 1.7mm, $\sigma_{rx,ry,rz}$=1.0°, 1.1°, 0.69°). A more challenging case (rx=10°) was also included. For comparison, the original plans were also recomputed on the new CTs, including table translations. The dose distributions were evaluated on the $V_{100\%}$ to the PTVs and 5mm rings around the PTVs (conformity). We also recorded the duration of the process.

Results

A DVH example for 1 setup error for 1 patient is shown in Fig. 1. The SWO results in an adapted plan that is more inhomogeneous (allowed for SRS) than the original and recomputed plan. An overview of all results is shown in Fig. 2. PTV coverage is slightly reduced, but acceptable, for most adapted (-1.9pp) and recomputed (-1.4pp) plans. Similarly, the plans are slightly less conformal, with the recomputed plans performing 1.7pp better in ring $V_{100\%}$ than the adapted. As can be seen in Fig. 2, the adaptation method is able to correct the large rx=10° setup errors (with a plan quality similar to that for the small setup errors), whereas the table correction completely fails target coverage (average $V_{100\%}$ of 65%). On average, the entire process from registration to plan export was completed within 14 (max 18) minutes.

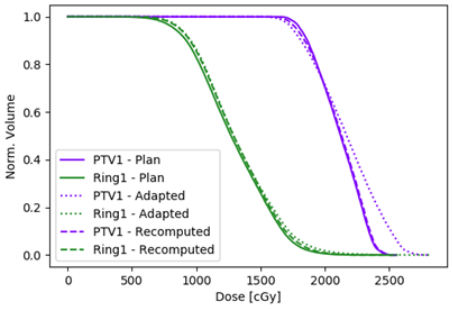

Fig. 1: DVHs for PTV and 5mm Ring (conformity) for one of the PTVs for the original, the adapted, and the recomputed plan.

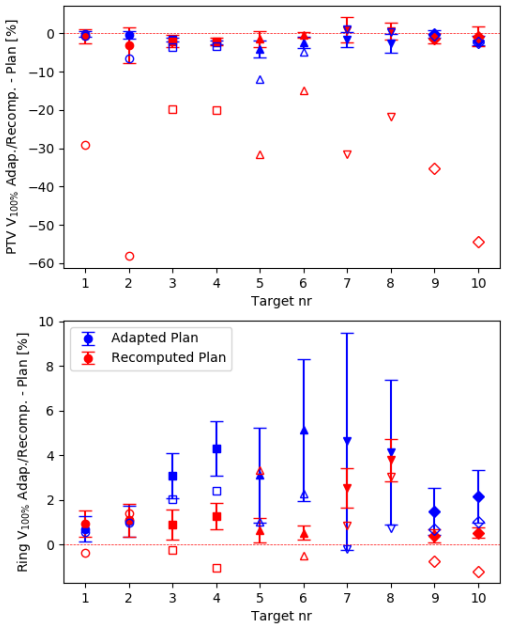

Fig. 2: The $V_{100\%}$ (averaged over 10 realistic setup errors, with error bars representing σ, different symbols representing different patients) for the PTV (top) and 5mm Ring (bottom). The value of the $V_{100\%}$ relative to the (original) Plan is plotted per target (2 targets for 5 patients). The open symbols represent a large setup error (rx=10°).

Conclusion

We have successfully developed a method to adapt multiple lesion brain SRS plans online based on CBCT. Whereas this new method performs similar to a physical table correction for our current brain SRS protocol and setup errors, it greatly outperforms the table correction for larger geometrical differences. This ability to correct larger setup errors could allow a PTV margin reduction and extend the use of planning with a single isocentre. The introduced method is not limited to rigid corrections and can be applied to other tumor sites. Ultimately, we consider the development of this method an important step towards full online adaptive radiotherapy.

EP-1986 Comparison of automatic OAR contour propagation from CT to MR lung images

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Purpose or Objective

For daily plan adaptation on the MR-Linac, fast and accurate methods of OAR contouring are required and it is envisaged that automatic contour propagation will play an important role.

MRI sequences differ in speed, with the DIXON VIBE being relatively quick, whilst acquiring multiple contrasts simultaneously. It is unknown whether contour propagation onto these images is as accurate as other slower sequences. The radial k-space stack-of-stars acquisition (STARVIBE) is commonly used in areas associated with motion, e.g. lungs, to reduce artefacts, while the DIXON sequence can be used as a basis for MR only planning.

This aim was thus to compare contour propagation from CT onto STARVIBE and DIXON images and to determine whether the fast DIXON would be a sufficient pre-treatment sequence.

Material and Methods

5 NSCLC patients were imaged mid-treatment on a diagnostic 1.5T MR (MAGNETOM Aera, Siemens Healthcare, Erlangen, Germany) using non-triggered sequences: STARVIBE (time = 7:21, spokes = 1050, with fat sat) and DIXON VIBE (time = 1:51, averages = 4), both with matrix 1.25x1.25x3.5 mm^3. Patients were scanned in the treatment position. The mean time between the two sequences was 25 mins. The DIXON water-only contrast was used for analysis.

MR images were first rigidly registered to the patients' CT planning scans in MONACO (Elekta AB, Stockholm, Sweden). Oesophagus, heart and spinal canal contours, drawn by radiation oncologist, were then propagated from the CT to each mid-treatment MR scan via deformable registration using ADMIRE (Elekta AB, Stockholm, Sweden). The resulting OAR contours were compared by volume, mean DTA and DICE index for both MR sequences.

Results

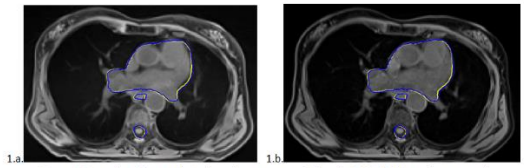

Figure 1. Oesophagus, heart and spinal canal contours overlaid on the STARVIBE (1.a, yellow contour) and DIXON (1.b, blue contour).

The average volume ratios (DIXON/STARVIBE) were 1.10, 1.01 and 1.00 for the oesophagus, heart and spinal canal respectively. Only the oesophagus volume was significant ($p = 0.01$).

The mean DTAs ± SD, were 0.94 ± 0.72, 1.23 ± 1.00 and 1.24 ± 1.70 for the oesophagus, heart and spinal canal respectively. The mean DTAs for OARs across the 5 patients are shown in figure 2. All OARs were < 2 mm mean DTA except P1 heart (2.1 mm) and P5 spinal canal (2.2 mm). DICE indices of 0.84 ± 0.02, 0.96 ± 0.02 and 0.87 ± 0.05 were obtained for the oesophagus, heart and spinal canal respectively.

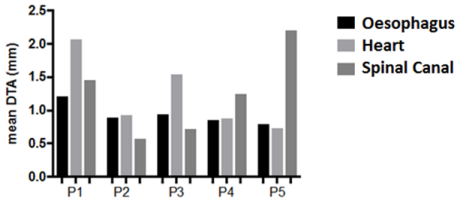

Figure 2. Mean DTA for oesophagus, heart and spinal canal contours on the STARVIBE and DIXON images for the 5 patients.

Conclusion

This work compared contours obtained via auto-contour propagation from CT to mid-treatment STARVIBE and DIXON VIBE images.

The mean volume difference for the oesophagus was significant. The mean DTA between the two MR scans was less than 2 mm in all but two instances. DICE was greater than 0.8 for all OARs. Differences could occur due to registration inaccuracies and also due to organ motion between scans.

The results indicate that the DIXON VIBE type sequence may be suitable for set up imaging on the MRL to reduce set-up times (DIXON <2 min, STARVIBE> 5 min). Auto-contour propagation must still be followed by clinician verification at this stage.Future work will compare OAR and GTV contours against clinician drawn contours in a larger sample.

EP-1987 Dose accumulation assessing the validity of reduced PTV margins in head-and-neck radiotherapy

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Purpose or Objective

Purpose: Emerging literature has reported reduced treatment toxicity while maintaining equivalent local-regional control rates after reducing planning target volume (PTV) margins from 5 to 3 mm for head-and-neck radiotherapy (HNRT). As we considered whether it was possible to implement reduced 3 mm PTV margins in our department, it was recognized that many aspects of HNRT including robustness of the planning solution for anatomical changes may influence treatment outcomes and should be considered when PTV margins are reduced. This retrospective study investigates the robustness of treatment plans using 3 or 5 mm PTV margins for anatomical changes. The results of this study can be used to develop strategies for treatment adaption based on objective criteria.

Material and Methods

Methods: Volumetrically modulated arc therapy (VMAT) plans for 12 patients using 3 or 5 mm PTV margins (Prescribed dose 54 Gy and simultaneous integrated boost volumes to 60 and 66 Gy in 30 fractions) were optimized using the local planning protocol. The planning CT (pCT) was first registered to each daily cone beam CT using deformable image registration (DIR). Subsequently, the inverse registration was used to reconstruct and accumulate the delivered dose to target and organ-at-risk (OAR) structures in the pCT scan. For the initial analysis, the coverage of the PTVs, clinical target volumes (CTVs) and salivary glands were assessed using the $D_{98\%}$, $D_{99\%}$ and D_{mean} respectively. The uncertainty of the reconstructed dose was assessed using an *in silico* model based on clinically observed deformations to determine the 95% level of confidence.