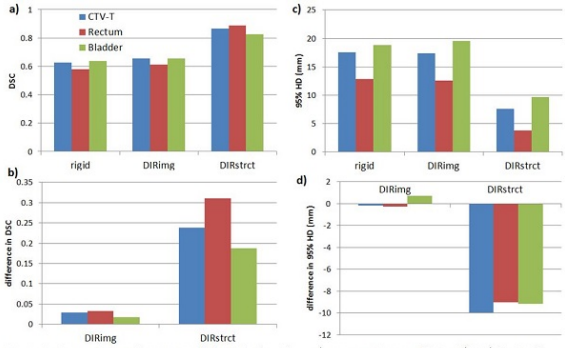

Figure 1: Geometric performance of the DIR algorithm. a) average Dice coefficient (DSC) for rigid registration and the two DIR methods. b) average improvement in DSC over rigid registration. c) average 95% Hausdorff distance (HD). d) average improvement in 95% HD over rigid registration.

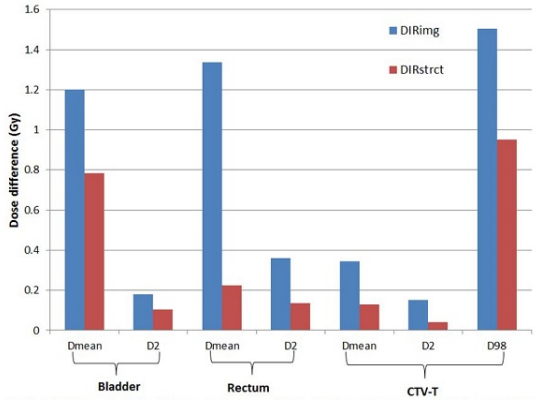

Figure 2: Average absolute difference in dose parameters between reference and deformed contours

Conclusion

The large deformations occurring in the female pelvis pose a challenge for accurate DIR. The overlap of deformed and delineated organs is generally not satisfactory when using DIR based on image information only, therefore hindering autocontouring. Deformation based on controlling structures delivers improved results, which may make accurate dose accumulation for the mentioned organs feasible, if all available images are manually contoured. Still, in extreme organ motion cases, also this approach led to poor results. Future studies will investigate this DIR method for CT-to-CBCT.

References

[1] O. Weistrand and S. Svensson, Med. Phys. 42: 40-53 (2015)

EP-1707 Dose of the day in Head-Neck cancer Tomotherapy: a DIR-based method's comprehensive validation

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Purpose or Objective

The aim of this study is to validate an original method for computing the dose of the day that employs deformable image registration (DIR) of the planning CT to MVCT taken during Tomotherapy (HT) for Head and Neck (HN) cancer, assessing both geometric and dosimetric accuracy.

Material and Methods

Planning CTs of 10 HN patients treated with HT (SIB: 54/66/69 Gy/30 fr or sequential boost: 54/66.6-70.2Gy/37-39 fr) were deformable registered to MVCT images acquired at the 15th fraction (processed with anisotropic diffusion filter) using a constrained intensity-based algorithm (MIM software). At the same treatment fraction, a diagnostic kVCT was acquired with the patient in the treatment position (CT15) and taken as reference. The original HT plans were recalculated on both the resulting deformable registered images (CTdef) and the CT15s. Dosimetric accuracy between CTdef and CT15 was assessed by local dose differences, 2D γ (2%-2mm) and 3D γ (2%-2mm) analysis in body voxels. These results were compared, in terms of 3D gamma, with the accuracy between dose distributions calculated on CT15 and on MVCT calibrated images; the performance were contrasted with the Kruskal-Wallis test. DIR's geometric accuracy was assessed by means of Dice Similarity Coefficients (DSC) between parotids/spinal canal manually contoured on CTdef and on CT15. A further analysis of dose to parotids/spinal canal was carried out for 5 patients by comparing DVHs calculated on the two images and the correlation between parotids mean dose and D5% and D1% to spinal canal values in the two situations (CTdef vs CT15).

Results

2D and 3D γ pass percentage were 95.4% ±0.8% and 95.0% ±0.7%. ΔD was < 2% in 87.9% ±1.3% of voxels. Dose computation on CTdef resulted to be equivalent to calculation on MVCT with correct Image Value Density Table (Kruskall-Wallis p-value = 0.60). The visibility of the anatomical structures, in particular of parotids, on CTdef was qualitatively much better than on MVCT. The agreement of parotid contours between CTdef and CT15 was very good: mean DSC values for L and R parotids were 0.85 and 0.88 (Table). A mean DSC value of 0.81 was found for the spinal canal. DVHs of parotids and spinal canal of CT15 and CTdef were very similar, as shown in Figure for an 'average" patient. In particular, linear correlation coefficient R^2 between parotid mean dose, D5%/D1% to spinal canal values calculated on CTdef and the corresponding values calculated on CT15 were 0.93, 0.93 and 0.89 respectively.

Conclusion

Deforming the planning CT to MVCT with an intensity-based method was proven to be accurate considering both dosimetric and anatomical similarities with respect to diagnostic kVCT. The dosimetry accuracy of the method is equivalent to dose computation on MVCTs, after proper voxel values calibration, with a much better visibility of anatomical structures on CTdef compared to MVCT. DSC values for parotids and spinal canal are comparable with inter-observers' contouring variability on kVCTs reported in literature.

Table: Dice coefficients for parotids and spinal canal.

Patient	Left parotid	Right parotid	Spinal canal
1	0.82	0.92	0.80
2	0.80	0.84	0.77
3	0.83	0.82	0.81
4	0.92	0.90	0.87
5	0.88	0.91	0.81
Mean	0.85	0.88	0.81

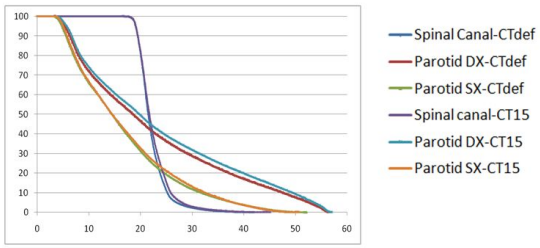

Fig: an example of DVH (relative volume, absolute dose [Gy]) comparison between CT15 and CTdef.

EP-1708 Investigating the reproducibility of geometric distortion measurements for MR-only radiotherapy

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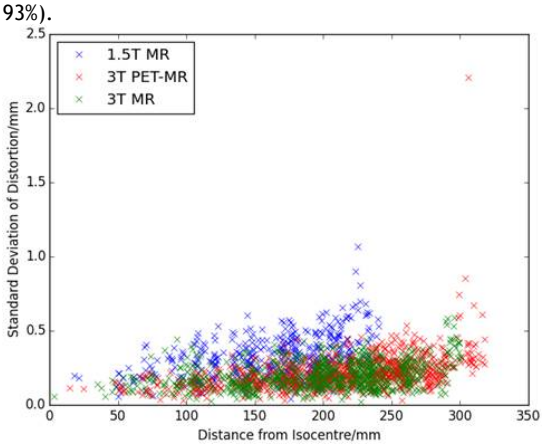
Purpose or Objective
MR imaging is increasingly used within radiotherapy due to its superb soft tissue contrast. However MR images can suffer from significant geometric distortions and for MR-only radiotherapy planning, images must be geometrically accurate. It is vital to measure these distortions and the aim of this study was to determine the reproducibility of distortion measurements using a commercial phantom for three different MR scanners from three different centres.
Material and Methods
Distortion was measured using a Spectronic Medical (Helsingborg, Sweden) large field of view geometric distortion phantom. Three different MR scanners were used: a 1.5 T Siemens Magnetom Espree (1.5T MR), a 3T General Electric Signa PET-MR (3T PET-MR) and a 3T Siemens Prisma (3T MR). To assess reproducibility, two sets of measurements were made on each scanner: three images were acquired without moving the phantom between scans (single set-up) and five images were taken with the phantom re-set up prior to each acquisition (repeated set-up). To investigate set-up sensitivity two separate scenarios were evaluated: one scan acquired with an intentional 1mm lateral offset applied and a second scan with an intentional 1° rotation. Each measurement contained two sequences, a 2D Fast Spin Echo and 3D Gradient Echo.
The phantom consisted of small spherical markers at known locations embedded in a low density foam. The images were analysed using the Spectronic Medical automatic distortion software. Distortion was defined as the magnitude of the vector difference between the known and measured position of each marker in the phantom.
Results
The mean of the standard deviations of all markers for each scanner, sequence and set-up are given in table 1. The mean standard deviations for the repeated set-up are larger than the standard deviations for the single set-up. All the mean standard deviations are less than 0.4 mm, which is smaller than the minimum voxel size of all acquired scans.

Scanner	Sequence	Mean Standard Deviation of Distortion/mm	
		Single Set-up	Repeated Set-up
1.5 T MR	2D	0.30	0.34
1.5 T MR	3D	0.26	0.32
3T PET-MR	2D	0.32	0.32
3T PET-MR	3D	0.12	0.21
3T MR	2D	0.11	0.21
3T MR	3D	0.11	0.20

Figure 1 shows an example plot of the standard deviation of distortion as a function of distance from the scanner isocentre for each marker.
The set-up sensitivity scans were compared with the repeated set-up scans. For each marker, the measured sensitivity scan distortion was compared to the repeated set-up mean and standard deviation distortion. For the 1mm lateral offset scan 90% of the markers agreed within two standard deviations of the mean of the repeated set-up scan (median of all scanners and sequences, range 78% - 93%). For the 1° rotation scan, 80% of markers agreed within two standard deviations of the mean (range 69% - 93%).



Conclusion
Geometric distortion measurements using the Spectronic Medical phantom and associated software appear reproducible, with smaller than 0.4 mm mean standard deviations for all scanners and sequences tested. Further work needs to be carried out to evaluate the sensitivity to set-up uncertainties.

EP-1709 Can atlas-based automatic segmentation contour H&N OARs like a physician?
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Purpose or Objective
Radiotherapy requires delineation of organs at risk (OARs). Manual contouring is time-consuming and subject to inter-user variability. A priori information can be used in Atlas-Based Automatic Segmentation (ABAS). Our study evaluates (i) if differences between structures contoured manually and with a Model-Based Segmentation (MBS) tool did not exceed inter-physician variability; (ii) if an un-biased dataset can be used to train and build an improved ABAS template; (iii) if the automatic segmentation is acceptable for all OARs.
Material and Methods
An analysis of original contours from kVCT of 30 Head and Neck (H&N) patients (pts) was carried out. Original manual contours were compared to the automatic contours performed by the MBS RayStation tool and were then used to train a customized ABAS template. This study is focused on parotids, mandible, spinal cord and brainstem. The analysis was performed using Dice Similarity Coefficient (DSC). The workflow is:

- · 2 expert radiation oncologists (ROs), in double-blind mode, gave a score [1÷10] of original manual contours;
- · 2 expert ROs, in double-blind mode, gave a score [1÷10] of automatic contours performed by the MBS tool;
- ·The original manual contours were reviewed/edited to adjust incorrect delineation;
- · The edited manual contours were compared with the MBS automatic contours;
- · The edited manual contours were used to train a novel ABAS template;
- ·CTs of 4 new pts were used to test the atlas developed. An expert RO performed a manual contours;