Feasibility of MR-only planning in a commercial treatment planning system

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Purpose

MR is of increasing interest in radiotherapy treatment planning due to its superior soft-tissue contrast. MRI can be used in combination with a planning CT to improve tumour delineation, and can also be used without the need for a CT in an MRI-only pathway.

This study aims to investigate the feasibility of an integrated MR-only planning solution in the commercial treatment planning system RayStation which relies on bulk-density assignment.

Methods

- CT and MR images were acquired in the treatment position for five prostate cancer patients.
- The planning target and OARs were delineated according to local standard practice.
- The bone ROI was created using a multi-atlas-based segmentation algorithm and manually modified if necessary. Figure 1.

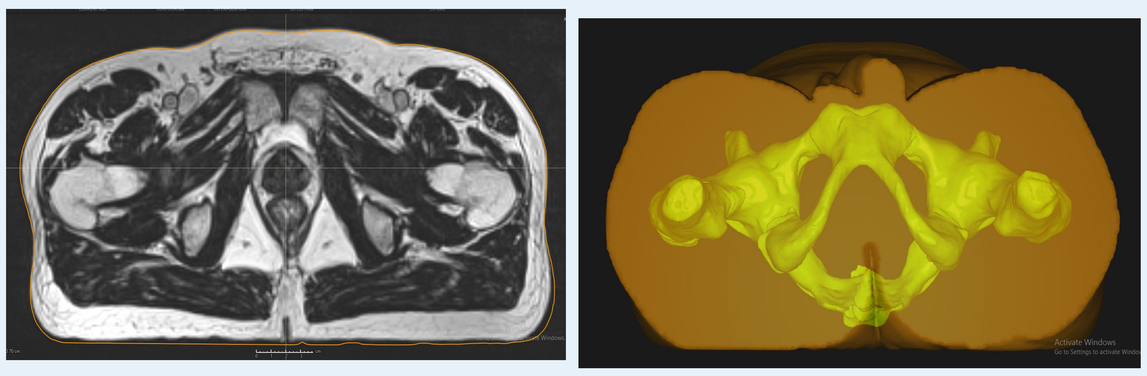

Figure 1: *Left – MRI, Right – Segmented bone contour*

- To minimize the effect of anatomical differences between the CT and MR image, the outline corresponding to the CT image was used for the MR image as well.
- Conventional VMAT plans were generated for each patient based on the CT image.
- The CT based plan was recalculated on the MR image by assigning bulk densities for soft tissue and bone.
- The calculated dose for the CT based plan was compared to the recalculated dose based on the MR image.

- A range of density pairs were evaluated for all patients, with densities from **0.95-1.03 g/cm^3 for soft tissue** and **1.15 - 1.65 g/cm^3 for bone**.
- Dose differences between the CT based and the MR bulk density based dose distributions were calculated for D1, D2, D50, D95, D98, D99 and average dose for the following ROIs: PTV, Rectum and Bladder.
- The density pair with the lowest dose difference between the CT and MR based calculations among all dose statistics and for all ROIs and patients, was considered the best and used for the rest of the study.

Results

With a mean absolute dose difference of 0.3% of the prescribed dose over all patients, ROIs and dose statistics, the following densities for soft tissue and bone was found to give the best results: 0.98 g/cm^3 for soft tissue and 1.25 g/cm^3 for bone. In Table 1 the average percentage dose difference of the prescribed dose is shown for each ROI and patient with these densities. The mean average dose was close to 0.0% and the standard deviation was 0.5% or less for all ROIs.

	PTV	BLADDER	RECTUM	Mean
Patient 1	-0,60	0,04	-0,01	-0,19
Patient 2	0,39	0,43	0,29	0,37
Patient 3	0,48	0,24	0,15	0,29
Patient 4	-0,50	0,01	-0,13	-0,21
Patient 5	0,14	0,14	0,16	0,15
Mean	**-0,02**	**0,17**	**0,09**	**0,08**
MAE	**0,42**	**0,17**	**0,15**	**0,24**
SD	**0,50**	**0,17**	**0,17**	**0,27**

Table 1: *The average dose difference of the prescribed dose between the MR image and the CT image in percent.*

Figure 2 shows the CT based dose distribution, MR based dose distribution and DVHs for PTV, Rectum and Bladder for Patient 1.

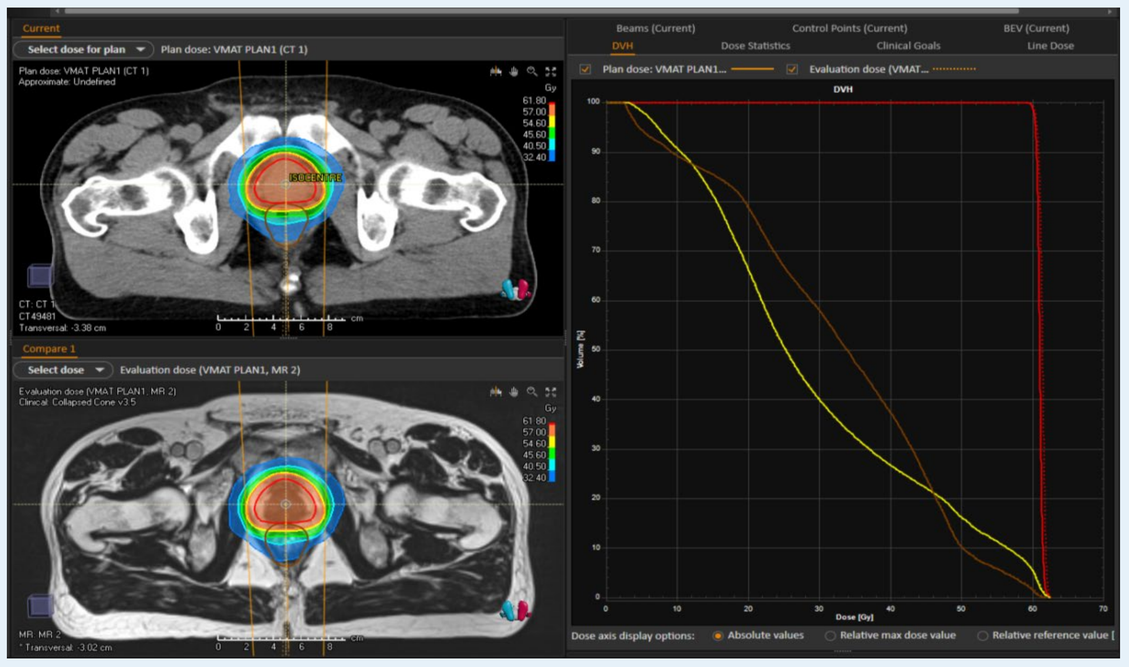

Figure 2: *Top left - Dose distribution on CT, Bottom left – Dose distribution on MRI, Right - DVH for PTV (red), bladder (yellow) and rectum (brown) CT based statistics solid lines, MRI statistics dashed lines.*

Conclusion

Using bulk-density assignment on MR images with suitable densities for bone and soft tissue results in clinically **insignificant** dose differences compared to dose calculated on the CT.

A limitation of this study is that the selection of 'best densities' may be population specific. However, the approach described can easily be extended to other centres by a local analysis of soft-tissue and bone densities on a sample of existing CT planning scans for the treatment site under consideration.

This study shows that MR-only planning using bulk-density assignment is feasible for prostate cancer patients.

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