Conclusion
Dose calculation accuracy as well as 2D and 3D patient positioning in IGRT for brain tumor patients based on synthetic CT is of sufficient quality and ready to be used in daily routine. This potentially facilitates the workflow, minimizes image registration errors, and reduces the number of diagnostics with ionizing radiation.

OC-0293 Dosimetric evaluation of deep learning based synthetic-CT generation for MR-only brain radiotherapy
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Purpose or Objective
Accurate dose calculation in MR-only radiotherapy (RT) requires synthetic CT (sCT) derived from MRI. Patients receiving brain RT may benefit from such an MR-only workflow. Deep learning based methods have previously been proposed for sCT generation. The purpose of this study is to evaluate the accuracy of dose calculations based on sCT images generated using a 2.5D convolutional neural network (CNN) optimized for brain images.
Material and Methods
We have retrospectively selected 52 patients receiving brain RT with both CT and MR scans available, a treatment plan and the absence of severe dental artefacts on CT. Multiple tumor locations were included, with prescribed dose (PD) ranging from 14-60Gy, the majority treated with dual arc VMAT. The MR sequence chosen for this study was a sagittal 3D T1w gradient echo MRI with a receiver bandwidth of 240 Hz (1.5T Philips Ingenia), as part of our clinical protocol for contouring. Patients were scanned in immobilization masks. CT scans (Philips Brilliance Big Bore) were preprocessed to remove the immobilization device from the background and linear normalization was applied to the MR scans. CTs were registered rigidly and resampled to MR resolution (0.87x0.87x1 mm). MR and CT images were used to train a 2D CNN to synthesize axial, sagittal, and coronal slices [J.M. Wolterink et al. LNCS 2017]. After training, a volumetric sCT was created by averaging the results obtained in the 3 directions. A two-fold cross validation was performed: In each fold 26 patients were used for training and 26 patients were used for evaluation. The 52 sCTs were evaluated by calculating mean absolute error (MAE) and mean error (ME) between CT and sCT (in HU). Clinical dose plans were recalculated in Monaco TPS (v 5.11.02, Elekta AB) on the resampled CT and sCT to determine the MAE and ME of the dose. Gamma analyses with 1%/1mm criterion were performed with a dose threshold of >50% of the PD.
Results
Training the CNN using a NVIDIA Titan X GPU took 30 hours and to generate a sCT volume from MRI took 1 min. An example including a dose difference image is shown (fig 1d). The table shows average MAE and ME within the intersection of the body contours, in bone and in soft tissue (obtained by thresholding). Mean gamma pass rate was 98.8% (2.1 SD, range:90.5-100%). An additional qualitative evaluation showed that sCTs are free of streaking artefacts in patients with dental implants (fig 2).

	Image CT-sCT (HU)			Dosimetric CT-sCT (%)	
	Total	Bone	Soft tissue	>50% (%)	In PTV (%)
MAE (SD)	67.4 (11.2)	174.1 (29.2)	21.6 (2.8)	0.58 (0.2)	0.78 (0.4)
ME (SD)	12.5 (9.0)	74.6 (41.3)	-1.6 (3.3)	-0.08 (0.3)	-0.13 (0.4)

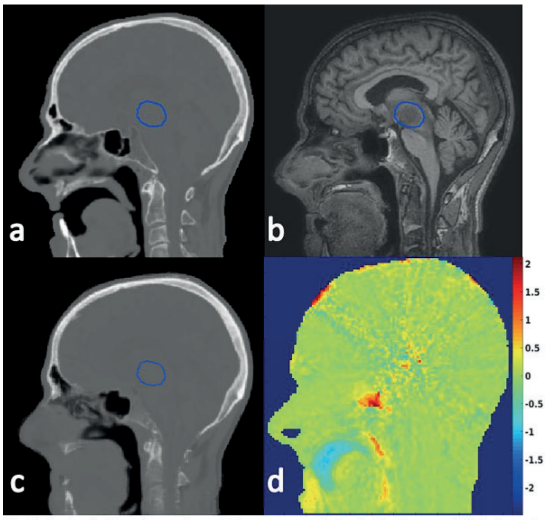

Fig 1: Sagittal slice of a patient with a metastasis in the brain stem (PTV shown). CT (a), MRI (b), sCT (c) and dose difference, in % of PD = 24 Gy (d). Note the difference in position of the tongue on CT and MRI. Differences in body contour and air cavities also result in dose deviations.

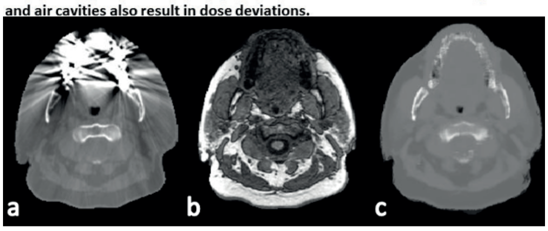

Fig 2: Transversal slice of CT (a), corresponding MRI (b) and sCT (c). The CT shows severe dental artefacts (excluded from the training data), whereas the generated sCT is without streaking artefacts.

Conclusion
The CNN trained in this study was able to generate a sCT volume in 1 min. The errors between original CT and sCTs were small and calculated dose distributions showed high accuracy. Besides being suitable for MR-guided RT which requires online sCT generation, this is a first step in achieving a fast MR-only workflow ('one stop shop') to decrease treatment time and burden to the patient.

OC-0294 MR-based synthetic CT with conditional Generative Adversarial Network for prostate RT planning
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Purpose or Objective
To enable MR-only planning and accurate MR-based dose calculations, so-called synthetic CT (sCT) images need to be generated. Recently, conditional Generative Adversarial Networks (cGANs) have been proposed as a general-purpose solution to image-to-image translation problems. By interpreting the generation of sCT images as an image-to-image problem, this work aims at