Conclusion: DIR-based registration methods showed that the vast majority of failures originated in the high dose target volumes and received full prescribed doses suggesting biological rather than technology-related causes of failure. Validated DIR-based registration is recommended for accurate failure characterization and a novel typology-indicative taxonomy is recommended for failure reporting in the IMRT era.

OC-0072

Respiratory time-resolved 4D MR imaging for RT applications with acquisition times below one minute

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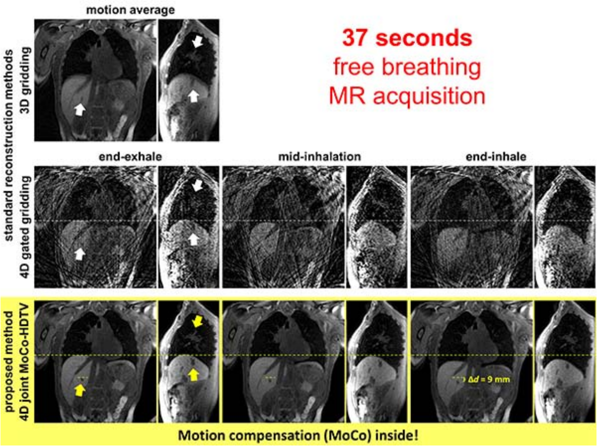
Purpose or Objective: 4D MRI has been proposed to improve respiratory motion estimation in radiotherapy (RT), aiming to achieve a higher treatment accuracy in the thorax and the upper abdomen. In contrast to 4D CT, acquisition time in 4D MRI is not limited by radiation dose, such that multiple breathing cycles can be imaged routinely. However, standard MR reconstruction methods, such as gated gridding, have limitations in either temporal or spatial resolution, signal-to-noise ratio (SNR), contrast-to-noise ratio (CNR) and artifact level or demand inappropriately long acquisition times. The purpose of this study is to provide high quality 4D MR images from super short acquisitions.

Material and Methods: MR data covering the thorax and upper abdomen of three free-breathing volunteers were acquired at a 1.5 T Siemens Aera system. We applied a gradient echo sequence with radial stack-of-stars sampling and golden angle radial spacing: total acquisition time: 37 s, slice orientation: coronal, field-of-view: 400×400×192 mm^3, voxel size: 1.6×1.6×4.0 mm^3, TR/TE = 2.48/1.23 ms, 240 spokes per slice, undersampling factor: 16.8, flip angle: 12°. MR data were sorted into 20 overlapping 10% wide motion phase bins employing intrinsic MR gating. Respiratory motion compensated (MoCo) 4D MR images were generated using our newly developed 4D joint MoCo-HDTV algorithm, which alternates between motion estimation and image reconstruction. With MoCo, each motion phase is reconstructed from 100% of the measured rawdata. In the motion estimation step, the motion vector fields (MVFs) are estimated between adjacent motion phases and regularized by cyclic constraints. Results were compared to the standard reconstruction methods 3D gridding and 4D gated gridding.

Results: 3D gridding reconstructions revealed strong blurring of structures in the lungs, in the diaphragm region and in the liver caused by respiratory motion. 4D gated gridding images were deteriorated by noise and severe streak artifacts, arising from high azimuthal undersampling. These artifacts obscured small anatomical structures. In contrast, 4D joint MoCo-HDTV reconstructions yielded appropriate image quality combining low streak artifact levels and high temporal resolution, SNR, CNR and image sharpness. Thus, the displacement between end-exhale and end-inhale of small liver structures could be determined, which was not possible using 4D gated gridding images due to their limited image quality.



Conclusion: 4D joint MoCo-HDTV facilitates 4D respiratory time-resolved MRI and provides respiratory MVFs at acquisition times below one minute. The method is promising for reliable target delineation in radiation therapy, patient-specific margin or gating window definition, and for adaptive planning based on the provided MVFs. The short acquisition time makes it attractive also for online imaging in an MR-LINAC setting.

Proffered Papers: Physics 2: Basic dosimetry

OC-0073

Difference in using the TRS-398 code of practice and TG-51 dosimetry protocol for FFF beams

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Purpose or Objective: The two most commonly used protocols for reference dosimetry in external beam radiotherapy are IAEA TRS-398 and AAPM TG-51. Increasingly flattening filter free (FFF) linacs are in clinical use and published theoretical analysis suggests that a difference of 0.5 % is expected between the two protocols (Xiong 2008).

Material and Methods: The Australian Clinical Dosimetry Service (ACDS) has measured FFF beam dose outputs on 11 linacs using both TRS-398 and TG-51 protocols. The response of an NE2561 chamber was modelled using DOSRZnrc. The model was used to study the difference in *kQ* in Varian and Elekta linacs when the flattening filter was removed, and when the flattening filter was replaced by a thin metal plate.

Results: Measured differences in dose output derived from TRS-398 and TG-51 protocols were less than 0.1 % for 6 MV FFF beams and less than 0.2 % for 10 MV FFF beams. Figure 1 shows the modelled response from the NE2561 for Elekta and Varian beams with the flattening filter, with the flattening filter removed, and with a thin metal plate replacing the flattening filter. The modelled FFF *kQ* as a function of TPR20,10 is 0.6 % lower than the *kQ* with flattening filter (WFF). This difference is reduced to 0.3 % when considering *kQ* as a function of %*dd*(10)x. Thus the measured difference in the TRS-398 and TG-51 protocols should be 0.3% according to the modelled results, however the average measured difference is less than 0.1 %. The commercial realisation of FFF beams includes a thin metal filter in the place of the flattening filter. When a 2-3 mm metal plate was included in the model, the difference between the FFF *kQ* and the WFF *kQ* was reduced to approximately 0.1%.