AbstractID: 11312 Title: Strategies and requirements of real-time MR imaging for integrated MRI+Linac systems

Purpose: Integrated MRI+linac systems can potentially yield complete spatio-temporal knowledge of the irradiated anatomy during beam-on - representing the ideal guidance strategy for 4D radiotherapy delivery. In this work, we investigate rapid imaging strategies for such devices to enable real-time, MR-guided, motion-adaptive radiation delivery.

Method and Materials: SNR in MR images is described by:

$$SNR \propto B_0 \times (\Delta x \times \Delta y \times \Delta z) \times \sqrt{T_{acq}} \ ,$$

where B_0 is the primary field, $\Delta x,\ \Delta y\ and\ \Delta z$ are voxel dimensions and T_{acq} is the acquisition time. We investigated trade-offs between SNR and two important design and operational parameters for MRI+linac systems – **(i)** B_0 , which impacts design complexity, and **(ii)** T_{acq}, which impacts the spatio-temporal accuracy of real-time guidance. In the first study, SSFP and SPGR sequences were employed to acquire 3D volumes (1.2 s/volume) and 2D coronal slices (0.3 s/slice) of the thoracic region from five human subjects (1.5T scanner). To simulate lower field-strength, image SNR was progressively degraded by adding increasing levels of gaussian noise. A fat deposit on the diaphragm was segmented in the noise-free and the degraded images and the error in the estimated position was computed. In the second study, faster acquisition through partial k-space scanning was simulated. A cylindrical water-filled phantom containing seven oil-filled cylinders was imaged and a progressively increasing number of mid-frequency phase encode lines were zeroed prior to reconstruction. The centers of oil-filled cylinders were auromatically segmented in the full and partial k-space acquisitions, and the positional error was computed with respect to the full k-space image.

Results: Positional errors of the anatomic feature were within 1.5 mm for a factor-of-6 SNR degradation, corresponding to B_0 = 0.25T. Partial k-space acquisition could be performed to increase acquisition speed by over a factor of 5, while maintaining sub-1 mm accuracy.

Conclusion: These initial studies indicate the feasibility of low-field, real-time MRI for intrafraction motion management using integrated MRI+linac systems.