AbstractID: 13434 Title: Real-time MRI for soft-tissue-based IGRT of moving and deforming lung tumors

Purpose: Integrated MRI+Linacs can potentially provide real-time soft-tissue-based image-guidance for lung cancer IGRT. Towards this, we investigate guidance strategies using prospective rapid lung MRI coupled with deformable image registration.

Method and Materials: All experiments were performed on a 1.5 T MRI scanner, using a 4-channel cardiac coil, under free-breathing conditions, without extrinisic contrast. A balanced steady-state free precession (b-SSFP) imaging sequence was optimized for prospective imaging and reconstruction. Two lung cancer patients (Pt#1: 4 cm tumor, right lower lobe, Pt#2: 6 cm tumor, left upper lobe) were imaged. A viscous fluid-flow-based deformable registration was applied to each MRI time series in order to determine motion trajectories of voxels within the field of view. These trajectories were used to characterize:

(i) motion of the tumor centroid.
(ii) relative trajectories of the tumor centroid and the diaphragm
(iii) relative trajectories of different points on the tumor – characterizing tumor rotation/deformation.

Results: The modified b-SSFP sequence yielded acquisition times of ~0.16s and ~1.5s for 2D and 3D acquisition, respectively.

Tumor trajectory analysis:

(i) significant cycle-to-cycle variation in tumor motion was observed in both patients
(ii) For Pt#1, the tumor centroid showed good correlation with diaphragmatic motion. For Pt#2, this correlation was relatively poor
(iii) Pt#1 did not exhibit significant tumor rotation/deformation. In Pt.#2, the trajectories of two points on the tumor showed maximum deviations of ~8 mm (superior-inferior) and 3.4 mm (anterior-posterior), indicating non-negligible rotation/deformation – likely due to the influence of the adjacent cardiac wall.

Conclusion: To our knowledge, this is the first demonstration of MRI for real-time imaging of lung cancer. The incorporation of these strategies into MRI+Linacs offers image-guidance capabilities that are not possible using current techniques: (i) soft-tissue-based rather than surrogate-based monitoring (ii) no fiducial implantation or imaging dose (iii) arbitrary slice selection and (iv) ability to monitor complex motion.