AbstractID: 8230 Title: 4D locally adaptive radiation delivery using integrated in-room MRI and DMLC tracking

Purpose: The ideal IGRT-based delivery to manage intrafraction motion has two requirements: complete spatio-temporal knowledge of the anatomy, and real-time beam adaptation corresponding to motion-induced anatomical changes. Toward this goal, we investigate an integrated strategy combining two powerful techniques – online image-guidance using fast cine-MR imaging (4D-MRI) and real-time, locally adaptive delivery using dynamic multileaf collimator (DMLC)-based tracking.

Method and Materials: Image SNR and, therefore, field strength (B_o) requirements for an integrated MRI+Linac for the task of radiotherapy guidance were investigated. Using multisection, multiphase steady-state free precession (SSFP) and spoiled gradient recall (SPGR) sequences, 3D volumes (1.4s/volume) and 2D coronal slices (0.5s/slice) of a volunteer's thoracic region were acquired with a 1.5T MRI. For each set, a region of interest encompassing the diaphragm was segmented and trajectories of superior-inferior and left-right motion were computed for voxels within. In order to simulate real-time imaging with lower field strength MRI+Linacs, the SNR for each set was progressively degraded and corresponding motion trajectories recalculated. 4D locally-adaptive IMRT was implemented using a DMLC tracking algorithm which adapts the beam aperture(s) in real-time using 3D position information from an independent monitoring system. The aforementioned trajectories were programmed into a high-resolution 3D-programmable motion platform and geometric accuracy of DMLC tracking was measured.

Results: The SSFP-acquired 2D and 3D images yielded adequate SNR for registration, while the SPGR sequence yielded faster acquisition but poorer SNR. For SSFP images, even with a factor-of-six SNR reduction (corresponding to B_o ~0.2T), no significant changes were observed in estimated motion trajectories. Finally, sub-millimeter tracking accuracy was observed for these traces for simultaneous target motion in the S-I and left-right directions.

Conclusion: These initial studies provide valuable insights into design requirements of integrated MRI+Linac systems and indicate that 4D-MRI combined with DMLC tracking represents a highly promising approach for intrafraction motion management.