

**Purpose:** Respiratory motion causes thoracic anatomy to change continuously in all four dimensions (4D = 3D+time). However, current image-guidance tools (e.g., 4DCT) provide only a reconstituted, single-cycle snapshot of motion, thereby ignoring complex cycle-to-cycle spatial and temporal effects. In this work, we investigate the use of rapid MRI as a truly 4D, non-invasive monitoring tool for lung SBRT

**Methods:** Under an IRB-approved protocol, two lung cancer patients were imaged under free breathing conditions, without extrinsic contrast, on a 1.5T MRI scanner using a 4-channel cardiac coil. A balanced SSFP sequence (TE/TR: 1.68/3.16 ms; FOV: 240x240 mm<sup>2</sup>; half-Fourier acquisition; voxel: 2.4x3x5 mm<sup>3</sup>) was used to acquire 2D+t and 4D (8 slices, parallel acceleration=4) time series for 20s and 60s respectively. For each 2D+t series, the tumor centroid, the diaphragm and ~15 points on the tumor boundary were manually contoured on one image frame. An optical fluid-flow-based deformable image registration algorithm was applied to the time series to map the motion trajectory of each point on each contour. A temporal smoothness constraint was imposed so as to avoid non-physical registration.

**Results:** Acquisition times of ~0.15s/frame and ~1.5s/volume were achieved for 2D+t and 4D acquisition, respectively. In each case, image quality was adequate to clearly delineate and monitor the motion of the tumor, the diaphragm and the cardiac wall. Both patients showed significant cycle-to-cycle variation in tumor position. One of the patients with a left mid-lobe lesion showed significant tumor deformation and rotation (>4 degrees) due to the combined influence of cardiac and diaphragmatic motion.

**Conclusions:** Rapid 2D+t and 4D MRI offers a highly attractive, non-invasive tool for characterizing respiratory motion from a truly 4D perspective. Such image-guidance will lay the groundwork for personalized motion management based on patient-specific, long-term monitoring, personalized 4D treatment planning and, if necessary, inter- and intra-fraction treatment adaptations.