Purpose: To evaluate the effect of an adaptive gating system on treatment accuracy and delivery time as compared to gating based only on an external surrogate.
Methods: Two studies were designed to simulate the process of treatment planning, patient setup, and treatment delivery for 1) external surrogate-based; and 2) adaptive gating. External surrogate-based gating used only chestwall motion to generate the respiratory gating signal, while adaptive gating updates the external/internal correlation periodically based on the location of implanted fiducial markers. Lung tumor trajectories with corresponding chestwall motions acquired from 8 patients with multiple days of radiation treatments. A total of 20,026 seconds of data from 163 treatment beams was used. The average target miss percentage is defined to be the percentage of beam-on time that the target is thought to be within the gating window but is actually outside of it. The average duty cycle is defined as the beam-on time divided by the sum of beam-on and beam-off time.
Results: The average target miss percentage for adaptive gating was 17.6% (range: 8.0-23.6%) and 22.6% (range: 8.1-44.5%) without adaptation. The magnitude of the average miss was 1.7 mm (range: 0.6-4.8 mm) with adaptation and 1.8 mm (range: 0.6-4.3 mm) without adaptation. The average miss percentage for misses of over 5 mm was 0.6 % (range: 0.0-3.3%) for adaptive gating and 0.9 % (range: 0.0-3.7%) without adaptation, suggesting that additional planning margins of 5 mm would mitigate most gating errors with either method. The average duty cycle using adaptive gating was 33% (range: 23-39%), compared to 45% (range: 35-57%) without adaptation.
Conclusion: We have shown that adaptive gating can improve the accuracy of gated treatments, at the cost of longer treatment times. However, both adaptive and non-adaptive techniques perform well if an additional planning margin of 5 mm is used.