Physics Proffered Papers 6: IGRT: 4D and Breathing Adapted

TUESDAY, MAY 10, 2011, 251 oral

GEOMETRIC ACCURACY OF DYNAMIC MLC TRACKING WITH AN IMPLANTABLE WIRED ELECTROMAGNETIC TRANSPONDER

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Purpose: Tumor motion during radiotherapy treatment delivery can substan- tially deteriorate the target dose distribution. A promising method to overcome this problem is dynamic multi-leaf collimator (DMLC) tracking, where the MLC aperture is continuously adapted to the tumor position. The purpose of this phantom study was to integrate a wired electromagnetic transponder local- ization system with DMLC tracking and to investigate the geometric accuracy of the integrated system.

Materials: DMLC tracking experiments were performed on a Trilogy acceler- ator (Varian Medical Systems, Palo Alto, CA) with a prototype DMLC tracking system. A wired implantable electromagnetic transponder (RayPilot, Micro- pos Medical AB, Gothenburg, Sweden) was mounted on a motion stage with a 3 mm tungsten sphere used for target visualization in MV images. The transponder signal was received by antennae arrays in the table top and used to generate a 3D transponder position signal with 30 Hz frequency. The po- sition signal was sent to a DMLC tracking program that continuously adapted the MLC aperture to the transponder signal position. A 10 cm circular MLC aperture was used in all experiments. Continuous MV images acquired at 7.5 Hz were used to determine the MLC aperture center position and the tung- sten sphere position in beam's eye view of the treatment beam. The track- ing system latency was determined as the time lag between the tungsten sphere motion and the MLC aperture motion in the MV images for a sinu- soidal motion. The geometric accuracy of the tracking system was measured by programming the phantom to reproduce four representative lung tumor tra- jectories (originally measured with a Cyberknife Synchrony system) and four representative prostate trajectories (originally measured with Calypso electro- magnetic transponders). Prediction was used for the lung tumor trajectories to account for the latency. For each trajectory, three treatments of 72 seconds duration were delivered: (1) a 358° arc field, (2) a vertical static field, and (3) a horizontal static field. The beam-target error was determined for each MV image as the 2D positional difference between the tungsten sphere and the MLC aperture center. The root-mean-square (rms) of the beam-target er- ror was determined for each field for each trajectory and compared with the would-be error without tracking.

Results: The tracking system latency was 140 ms. Fig. 1 shows the 2D rms beam-target errors for each trajectory for the arc fields. Tracking reduced the mean rms error from 4.9 mm to 1.0 mm for lung tumor trajectories and from 3.4 mm to 0.7 mm for prostate trajectories. Static fields gave very similar results.

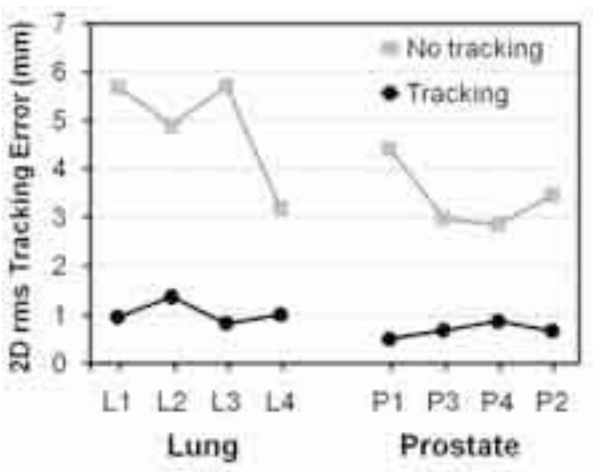

Figure 1. 2D rms beam-target error with and without tracking during arc treatments for four lung tumor trajectories (L1-L4) and four prostate trajectories (P1-P4)

Conclusions: DMLC tracking was integrated with a novel electromagnetic transponder localization system and investigated for arc and static field de- livery. The system provides sub-mm geometrical errors for most trajectories. The tracking latency is the shortest reported so far for DMLC tracking.