Purpose: To demonstrate for the first time MLC tracking of respiratory motion based solely on x-ray motion monitoring in the unique in-line geometry.

Methods: A Siemens Artiste linac was equipped with two flat-panel imagers (FPI), one directly underneath the linac head, the other underneath the patient couch. The kV x-ray beam pointed towards the linac head and was tilted by 5.4deg from the MV treatment beam axis, such that the two beams were spatially separated on both FPIs. A programmable phantom with an embedded metal marker reproduced a 3D lung tumor motion trace. The marker position was automatically detected in the kV images, which were acquired on the upper FPI at a frame-rate of 7.1Hz. The marker coordinates were sent to our tumor tracking system, which adapted the aperture of a Siemens 160 MLC in real-time. System latency was compensated through a linear regression predictor, which was trained on a 40s breathing data window. The lower FPI was used to assess both the system latency and the geometric tracking accuracy by identifying MV field and marker position. System latency was determined by tracking a sinusoidal motion trace without prediction and calculating the phase difference from least squares fits to the phantom and treatment field trajectories. Radiochromic films were used to assess dosimetric tracking accuracy. A static radiation delivery to the non-moving target served as reference for the delivery to the moving phantom with and without tracking.

Results: The total system latency was 740ms. Respiratory motion tracking yielded root mean squared deviations between phantom and MV field positions of 1.71mm (1.26mm) parallel (perpendicular) to the leaf travel direction. 2%/2mm gamma failure rates were decreased from 42% to 20%.

Conclusions: We achieved accurate MLC tracking of irregular breathing motion (perpendicular to the treatment beam) based solely on x-ray imagery.

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