Purpose: We have proposed a novel real-time tumor localization method, kilovoltage (kV) intrafraction monitoring (KIM), in which the intrafraction 3D tumor position is continuously measured during intensity modulated arc therapy (IMAT) by a gantry-mounted kV x-ray imager. This study reports the first clinical implementation of this method in patients with localized prostate cancer.

Methods: In an ethics-approved study, 10 prostate cancer patients with implanted fiducial markers underwent conventionally fractionated IMAT. During treatment, intrafraction prostate motions were tracked using KIM at a rate of 5 or 10Hz. The kV imager acquired 2D projections of the prostate markers. Post-treatment, markers in the images were segmented to obtain 2D positions. 3D positions were reconstructed by maximum likelihood estimation of a 3D probability density function. Trajectories were analyzed to determine the motion type and the percentage of time the prostate was displaced for more than 3mm, 5mm, 7mm and 10mm.

Results: Various prostate trajectories were observed (e.g. continuous target drift, transient excursion, stable target position, persistent excursion, high-frequency excursions and erratic behaviour). Over all patients, 3D displacements exceeding 3mm, 5mm, 7mm and 10mm were observed 5.6%, 2.2%, 0.7% and 0.4% of the time respectively. For individual patients, 3D displacements exceeding 3mm over all fractions ranged from 0.0% to 23.8% and 3D displacements exceeding 5mm ranged from 0.0% to 10.0%. For all patients, the left-right (LR), superior-inferior (SI) and anterior-posterior (AP) standard deviation of systematic setup error was 0.3mm, 0.2mm and 0.2mm, respectively. The LR, SI and AP standard deviation of random error was 0.7mm, 1.1mm and 1.1mm, respectively.

Conclusions: Our results demonstrate that KIM is a clinically viable and objective method for monitoring prostate motion during treatment. KIM only requires a single kV imager, which is commonly available, enabling its widespread implementation.

Funding Support, Disclosures, and Conflict of Interest:

Research supported by NIH/NCI R01 93626