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Abstract

Prostate Motion during Stereotactic Body Radiation Therapy (SBRT) on a Robotic Linear Accelerator

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Objectives: Stereotactic Body Radiation Therapy (SBRT) is gaining prominence as an excellent treatment option for men with favorable risk prostate cancer. Because of the high doses per fraction, planning target volume (PTV) margins are tighter than with conventionally fractionated radiation in order to minimize bladder and rectal exposure. The PTV margin accounts for prostate motion. The magnitude of motion in a given patient is unclear and varies greatly depending upon bladder and rectal filling. Our study seeks to quantify the range of translational and rotational motion during prostate SBRT on a robotic linear accelerator so as to better inform physicians who do not have the capability of performing real time tracking what the preferred PTV margins should be to ensure adequate target coverage.

Methods: Thirteen patients were included in this analysis, most of whom were treated on RTOG 0938 in either 5 or 12 fractions. After this trial closed to accrual, subsequent patients were treated as per this protocol. All patients performed a bowel prep prior to each treatment. The robotic linear accelerator that we used for treatment has a unique tracking system, which evaluates and corrects for prostate motion in real time using 3-4 implanted gold fiducials. During treatment, pairs of orthogonal X-rays are taken roughly every 15-30 seconds or more often if excessive motion is detected. Translational motion in the x (superior/inferior), y (right/left) and z (anterior/posterior) directions as well as rotational motion (roll, pitch and yaw) are tracked. We analyzed the log files for each fraction from all 13 patients and then extracted the translational and rotational values at various time points. We selected time points where the most amount of motion was present so as to capture the extremes of motion. The mean, minimum and maximum values in each direction were determined for each fraction and the 95th percentiles of motion were used to determine margin recommendations. We also estimated the percentage of time that the motion exceeded the margin recommendations.

Results: A total of 1,997 translational and 1,974 rotational time points were analyzed. The average treatment time per fraction was 46 minutes. The 95th percentiles for translation were as follows: x: 3.60 mm superior and 2.94 mm inferior; y:1.40 mm right and 1.63 mm left; z: 3.02 mm anterior and 1.08 mm posterior. The 95th percentiles for rotation were as follows: roll: 1.70 right and 1.77 left, pitch: 3.20 degrees head up and 5.02 degrees head down and yaw: 2.02 degrees clockwise and 1.66 degrees counterclockwise. For all patients, the motion exceeded 5

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mm for the following percent of time: x: 1.74%, y: 0.2%, z: 0.6%. and 5 degrees for the following percent of time: roll: 0.3, pitch: 1.9, yaw: 0.20.

Conclusions: Using real time tracking, we found that the prostate moves considerably during treatment due to changes in bladder and rectal filling. The greatest translational motion was seen in the superior/inferior and anterior/posterior directions while the greatest rotational motion was seen in pitch. An SBRT platform that tracks and corrects for this motion in real time is ideal. However, if one does not have this capability, then a PTV margin of 3-5 mm would adequately account for the motion seen in most patients with only very short periods of time where the prostate may potentially be outside of this volume.