SBRT Lung Treatment Tracking: Dosimetric Comparisons of Spinal-based vs. Synchrony-based Tracking

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Abstract

Objectives: Lung tumor motion is coincident with patient breathing during Stereotactic Body Radiation Treatment (SBRT). Ideally, the CyberKnife platform uses fiducials implanted in the tumor or lung tumor density as the mechanism to generate the motion pattern. However, some patients are not eligible for fiducial placement and/or have tumor characteristics that preclude density-based tracking. For these patients, tracking spinal column relative to the tumor provides a viable alternative. The purpose of this study is to compare Optically Stimulated Luminescent Dosimeter (OSLD) measurements from each tracking approach with the values obtained from Monte Carlo algorithm.

Methods: We used a CIRS Xsight Lung Tracking Phantom with a longitudinal motion column. An acrylic cube with fiducial marker was custom-made to fit the column. This cube hosts OSLDs, one located at the superior edge, two in the center, one at the inferior center. After being exposed to ionizing radiation, the OSLDs will illuminate depending on the radiation dose absorbed and the intensity of the stimulation light. The lung phantom was CT-scanned at inhalation and exhalation position. For Synchrony Tracking, the acrylic phantom in exhalation scan was expanded 3mm to create a planned tumor volume (PTV) for dose calculation. For Spinal Tracking, internal tumor volume (ITV), a combined inhale and exhale volume, is expanded 3mm to become the PTV. The Monte Carlo algorithm was used for inhomogeneous lung calculation.

Results: There are total three sets of OSLD were irradiated. The OSLDs in the Synchrony Tracking received 501-507 cGy, 609-611 cGy, and 550-578 cGy at superior, middle, and inferior positions, respectively. The corresponding Monte Carlo dose calculations from Accuray Multiplan showed 514 cGy, 610 cGy, and 555 cGy. The OSLDs in the Spinal Tracking received 491-531 cGy, 576-624 cGy and 594-618 cGy. The corresponding Monte Carlo dose calculation showed 501 cGy, 605 cGy, and 586 cGy. In terms of percentage differences: for synchrony tracking, results at the center of the tumor were -0.16% to -0.33%, the superior edge was -0.99 to -1.34%, and the inferior center -0.66% to 4.17%. For Spinal Tracking, the differences at the tumor center, superior surface edge, and inferior surface center were -7.69 to 3.14%, -6.86 to 6.09%, and -4.02 to 2.98%, respectively.

Conclusions: Synchrony tracking demonstrated superior level of agreement with Monte Carlo calculations compared to Spinal tracking. The greater level of disagreement with Spinal-based
tracking is likely due to an Interplay Effect. CyberKnife beams only aim at a portion of the ITV at a time and tumor can move in and out of the radiation field. The duration of each beam and tumor motion pattern may enhance the Interplay Effect. The clinical relevance and relative differences of the aforementioned tracking mechanisms requires further investigation.