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Abstract

Obtaining submillimeter targeting accuracy for lung tracking during end-to-end testing of a robotic radiosurgery system

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Objectives: It is desired to have submillimeter targeting accuracy during robotic radiosurgery, even when tracking moving lung tumors. End-toend (E2E) testing is used to verify the system's ability to achieve this level of accuracy. The treatment planning system for Accuray's CyberKnife system is able to automatically center the calculated dose distribution on the target for the purpose of E2E testing. In its most recent software version, Precision 1.1, the treatment planning system is only able to center the dose distribution calculated using the ray tracing algorithm. The ray tracing algorithm's inaccuracy within lung tissue causes the calculated dose distribution to be centered incorrectly resulting in a failed E2E test (targeting error > 0.95mm). The purpose of this study is to present a manual method of centering the dose distribution on the target using the Monte Carlo algorithm in order to obtain the desired submillimeter targeting accuracy during E2E testing of Xsight lung tracking. Methods: Isocentric treatment plans were created on an anthropomorphic thorax phantom using the standard E2E automated workflow that centers the ray tracing generated dose distribution on the target. The dose distribution was then recalculated with the same beam geometry using the Monte Carlo algorithm, and a contour was created from the appropriate isodose surface. The difference in coordinates between the centroid of the contoured isodose surface and the centroid of the target was used to calculate the necessary shift in isocenter position to align the two centroids. Both the shifted and nonshifted isocenter plans were delivered to the moving thorax phantom (3cm of motion in the sup/inf direction) using CyberKnife's Xsight Lung tracking. Film placed inside the target volume was analyzed to determine the actual difference between the centroid of the target volume and the measured dose distribution, which is a measure of the targeting accuracy of the system. This process was repeated 3 times for both the fixed and iris collimator. Results: The isocenter shift needed to center the Monte Carlo generated dose distribution on the target was 0.4mm anteriorly and = 0.1mm in the left/right and sup/inf direction. The primarily anterior shift is due to the beams transversing a greater length of lung equivalent material in the ant/post direction and the asymmetry of the beam geometry in the ant/post direction. The average total targeting error for the nonshifted and shifted E2E plans delivered to the phantom was measured to be 1.12 and 0.84mm, respectively for the fixed collimator and 1.04 and 0.83mm, respectively for the iris collimator. As expected, the largest difference in targeting accuracy was in the ant/post direction, where the targeting error decreased for the fixed and iris collimators by 0.39 and 0.47mm, respectively. Conclusions: The ray tracing algorithm is insufficient for accurately calculating dose distributions in the lung and leads to failing results of E2E testing of Xsight lung tracking on the CyberKnife system. Therefore, a manual method of creating E2E treatment plans using the Monte Carlo algorithm has been

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presented. Using this method, we were able to verify the submillimeter targeting accuracy of Xsight lung tracking on the CyberKnife system with total targeting error results ranging from 0.75 to 0.95mm.