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Determination of Treatment Margins for Head and Neck Tumors Treated with a Robotic Radiosurgery System Using Spine or Skull Tracking

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Abstract

Objectives: Robotic radiosurgery relies on imaging of fiducial markers, bony anatomy, or in some lung cases the tumor itself, to localize the target volume at the time of treatment. When using bony anatomy as a surrogate to localize soft tissue targets, there is an uncertainty in the localization of the target itself due to positional changes relative to the bony anatomy being tracked. The two purposes of this study are: (1) determine whether the spine or skull is a better bony anatomy surrogate depending on the location of the tumor; and (2) quantify the required treatment margins for head and neck tumors when aligning to the spine or skull.

Methods: A retrospective study of 16 head and neck cancer patients treated with stereotactic body radiation therapy (SBRT) on gantry-based linear accelerators was done by collecting data from 81 daily cone-beam computed tomography (CBCT) images. At the time of treatment, each CBCT was aligned to the reference planning CT based on tumor position. Using the Offline Review module in Aria version 11, rigid registrations were performed to realign the daily CBCT to the reference planning CT using both the spine and skull, separately, as the basis of the registration. Shifts from the treatment position to the new positions in the vertical, lateral and longitudinal dimensions were recorded. The magnitude of the shifts and the location of the tumor were used to classify each patient into the most appropriate tracking method (spine or skull), and the data were stratified accordingly. The margins needed to adequately cover the treatment volume with the 95% isodose surface for 90% of the patient population were calculated based on van Herk's margin recipe using the per patient mean and standard deviations of the shifts in each dimension.

Results: When the superior border of the tumor was located above the C1 vertebra, aligning to the skull required an average 1.0 mm smaller total shift compared to aligning to the spine. All other tumors had an average 1.0 mm smaller total shift when aligning to the spine; therefore, superior tumor extent was used to classify patients. When using spine tracking, a margin of 3.0 mm, 2.7 mm and 0.17 mm was calculated in the vertical, longitudinal and lateral dimensions, respectively. When using skull tracking, a margin of 1.5 mm, 1.7 mm and 1.7 mm was calculated in the vertical, longitudinal and lateral dimensions, respectively.

Conclusions: An additional margin is needed to account for uncertainties in head and neck tumor location when the spine or skull is used as a surrogate for patient positioning during

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robotic radiosurgery. For patients with tumor extent superior to the C1 vertebra, we recommend using skull tracking with a uniform 2 mm margin; and for patients with the entire tumor at the C1 vertebra and inferior, we recommend using spine tracking with a uniform 3 mm margin.