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Abstract

Evaluation of the dose delivery accuracy of three lung tumor tracking modes available on a robotic stereotactic body radiotherapy (SBRT) system

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Abstract

Objectives: Fiducial-free treatments have emerged as a new solution for early stage non-small cell lung cancer. The robotic SBRT system allows 3 different lung tumor tracking modes: tumor tracking based on two stereoscopic views, tumor tracking based on one stereoscopic view and spine tracking (when tumor is not visible on stereoscopic views). The goal of this study was to evaluate the dose delivery accuracy for each tracking mode using a dynamic anthropomorphic thoracic phantom and EBT3 Gafchromic films.

Methods: An original experimental plan was specially designed for this study. The dynamic phantom was composed of a programmable dynamic platform, an anthropomorphic thoracic phantom with a tumor insert that can accomodate Gafchromic films, and a sheep spine fixed to a frame. Respiratory cos^4 shaped motions were programmed with amplitudes ranging from 0.5 cm to 2 cm in the superior-inferior direction and an amplitude of 0.5 cm in the right-left direction (one view stereoscopic case). 4D images of the setup were acquired for those different breathing patterns. Ten respiratory phases were retrospectively sorted and exported to the treatment planning system. Non-isocentric and isocentric treatment plans were performed on the max-exhale CT scan. Dose calculation was made with the Ray-Tracing (RT) algorithm and the final dose calculation with the Monte Carlo (MC) algorithm. As spine tracking treatments required ITV based plan, a time-weighted cumulative dose profile was calculated from 4D-CT data set. Tracked dose measurements were performed using EBT3 films placed in the coronal plane of the moving phantom. The 2D measured and calculated dose maps were compared and analyzed by local gamma index (3%/3mm, 20% and 50% threshold) using a commercial software. At the center of the tumor, measured dose profiles along the superior-inferior motion direction were also analyzed.

Results: Gamma passing rates ranged from 92.9% to 95.6% for all tracked measurements based on one and two stereoscopic views. Very good agreements were found between calculated and measured dose profiles for those treatments. Concerning spine tracking treatments, for which dose calculation was performed on the end–exhale CT scan (corresponding to one static tumor position), gamma pass rate results did not satisfied the 90% pass rate recommended by the AAPM Report 135 (31.2%-66.2%). However the time-weighted cumulative dose profile was in very good agreement with the measured profile for the isocentric spine tracking treatment.

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Conclusions: Tumor tracking based on one and two stereoscopic views were evaluated for normal breathing pattern and treatment plan calculated with MC in terms of dose delivery accuracy. For the spine tracking, 4D dose accumulation was necessary to accurately evaluate the dose received by the tumor. In further experiments, the dosimetric impact of irregular respiratory motion will be studied for each type of tracking.