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2511 Target registration error with three-dimensional surface imaging in setup of image-guided partial breast irradiation

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Purpose

External beam partial breast irradiation (PBI) requires accurate localization of the target volume for each treatment fraction. Pre-treatment megavoltage or kilovoltage (kV) imaging can be used as an alternative to standard laser-based setup methods. These imaging modalities often rely on bony landmarks or radio-opaque clips implanted in the treatment area at the time of surgery. This study compares video-based three-dimensional surface imaging of the breast with clip-based kilovoltage imaging for patient setup.

Materials/Methods

Implanted clips are assumed in this study to be an accurate surrogate for the location of the target volume. The prescription for PBI treatment calls for 32 Gy to be delivered in 8 fractions over 4 days using both photon and electron beams. Patients were treated on a linear accelerator with dual gantry-mounted kV imagers capable of acquiring simultaneous orthogonal radiographs. Patients were initially aligned using standard lasers and then anterior-posterior and lateral kV images were taken prior to each fraction. Shifts were calculated by registering the treatment day images with digitally reconstructed radiographs (DRRs) from CT simulation. These shifts included translations but rotations were ignored. After shifting the patient, a second set of orthogonal kV images was taken to verify the target location after the move. Three-dimensional surface video images were also taken at the time of laser setup, after shifting the patient based on the kV images, and at the end of treatment. Video-based patient shifts were calculated using 3D surface alignment methods, and compared with the ground-truth radiographic alignment. Surface matching was done to define the transformation using both video images from a single fraction as a reference, and the daily laser setup video images as a reference to test the effect of intra- and inter-fraction variations on the video system.

Results

In an example patient, the average daily shifts, based on kV imaging, were 4.6 mm in the anterior/posterior direction, 2.9 mm in the superior/inferior direction, and 4.4

mm in the lateral direction. The average differences between the kV-based clip registration and the 3D video-based surface fitting (using the daily laser image as a reference) were 1.3 mm in the anterior/posterior direction, 1.4 mm in the superior/inferior direction, and 1.8 mm in the lateral direction. The maximum discrepancy between the setup modalities for any fraction, in any direction, was 4 mm. Pre- and post- treatment video images show that patient motion during the treatment session is typically less than 2-3 mm. Using the video images following radiographic alignment for the first fraction as a single reference, the surface alignments for subsequent fractions differed by less than 3 mm on average, suggesting that surface deformation over the course of treatment can be minimal. The correlation of surgical clips with other anatomical landmarks, such as vertebral bodies and ribs, was also explored. Data from patients on protocol will be presented.

Conclusions

Kilovoltage setup and video-based 3D surface fitting for PBI patients agree well based on initial results. This suggests that the surface of the breast may be a reasonable surrogate for the treatment volume, as delineated by surgical clips.