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186 Comparison Of Target Registration Errors for Multiple Modalities in Image-Guided Partial Breast Irradiation

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Purpose/Objective: External beam partial breast irradiation (PBI) requires accurate localization of the target volume for each treatment fraction. This study compares several methods of target localization, including standard laser-based setup, kilovoltage (kV) imaging of the chest wall, kV imaging of surgical clips implanted near the seroma, and video-based three-dimensional surface imaging of the breast.

Materials/Methods: Seven patients treated with external beam PBI were considered in this study. The prescription for PBI treatment calls for 36 Gy to be delivered in 9 fractions over 5 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. Implanted clips are assumed in this study to represent the “ground truth” position of the location of the target volume. 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 clip positions in the daily treatment images with the clip positions in the 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 and to quantify the residual target registration error (TRE) of clip-based image guidance. The target registration error of chest wall localization was determined by retrospectively aligning the chest wall from the daily kV images to the DRR. The difference in clip position from chest wall and clip-based image guidance is defined as the chest wall target registration error. 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 to determine the surface imaging TRE. All setup images (kV and surface images) were taken at exhale to eliminate the effects of respiratory motion. Respiratory motion was further studied by capturing sequences of surface images over the course of several breathing cycles.

Results: The median TRE of laser-based setup was 7.2 ± 4.3 mm (one standard deviation) and the median TRE of chest wall alignment was 7.5 ± 7.6 mm. The TRE decreased when using either clip-based or surface imaging target localization. The median TRE of clip-based localization was 2.5 ± 1.2 mm and the median TRE of surface imaging was 3.3 ± 1.5 mm. The median difference in patient position pre- and post- treatment surface images was 2.4 mm. Surface deformation of the breast during treatment was typically less than 2 mm. Systematic changes in clip position from the time of CT simulation to the initiation of radiation therapy were on the order of 3 mm.

Conclusions: Kilovoltage setup using implanted clips and video-based 3D surface fitting are more accurate methods of localization than standard laser or chest wall methods. The target registration errors for clip-based and surface-based imaging agree within 1 mm. This suggests that the surface of the breast may be a reasonable surrogate for the treatment volume, as delineated by surgical clips.