Evaluation of interfraction motion of the Strut-Adjusted Volume Implant (SAVI) using 3D reconstruction from CT scout images

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Motivation

The Strut-Adjusted Volume Implant (SAVI) is a partial breast irradiation applicator. The SAVI uses multiple catheters to provide excellent target volume coverage and normal tissue (skin and lung) sparing [1-3]. In order to precisely deliver radiation to the target, it is important to ensure the position of the applicator and reproducibility of the patient setup.

We developed a method to reconstruct the 3D device location using scout images to provide applicator position and proper expansion verification. We also used this technique to evaluate interfraction motion.

Results

The accuracy of 3D reconstruction:
The average distance between the marker positions reconstructed using the scout images and the CT images was 0.76 ± 0.28 mm (0.26–1.26 mm).

Interfractional device movement:
Using the daily CT images, the average interfraction motion of the device in the SI, AP, and LR directions, and 3D with standard deviation (range) was 0.50 ± 0.41 mm (0.07–1.52 mm), 0.86 ± 0.54 mm (0.17–1.88 mm), 0.68 ± 0.49 mm (0.02–1.67 mm), and 1.37 ± 0.51 mm (0.54–2.0 mm).

Using the scout image data, the average interfractional device movement in the SI, AP, and LR directions, and 3D was 0.51 ± 0.46 mm (0.00–1.67 mm), 0.95 ± 0.81 mm (0.07–2.62 mm), 0.73 ± 0.61 mm (0.03–2.26 mm), and 1.56 ± 0.68 mm (0.49–2.8 mm). Three radio-opaque markers from the post-operative scan (black dot) and setup scans prior to each fraction represent interfractional movement of the device.

Materials and Methods

Breast Phantom Study:

Patient Study:

CT images

AP and LAT Scouts

3D reconstruction and interfractional movement of the SAVI:
The SAVI device was implanted in a lumpectomy cavity. The patient was aligned by CT lasers and skin tattoos to ensure reproducible setup. A post-operative CT scan was performed for treatment planning. The patient was treated in 10 fractions over the course of 5 days. Daily CT scans and anterior and lateral scout scans were acquired prior to each fraction. Radio-opaque markers located on three of the struts (numbers 2, 4, and 6) were localized using a peak detection filter. The location of each marker on the 2D scout image was backprojected towards the CT X-ray source. Each 3D marker position was reconstructed at the backprojection intersection [4]. The 3D marker position was compared to the location in the 3D CT image. The interfractional displacement of the device was assessed from the reconstructed marker locations.

Conclusions and Future Work

• We developed a novel method to reconstruct the 3D location of the SAVI applicator using 2D scout images and validated the 3D reconstruction with 3D CT images.
• We demonstrated that the SAVI interfraction motion can be accurately measured using the scout images. The patient setup for partial breast brachytherapy can be improved by correcting the applicator displacement.
• In addition, the proposed technique will reduce the total number of CT scans and dose to patients. We are currently working on applying this technique to 15 patients being treated with the SAVI applicator.

Bibliography


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