Real time monitoring of anatomy during IMRT and VMAT breast radiotherapy using EPID imaging

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INTRODUCTION

For left-sided breast radiotherapy, DIBH can reduce the dose to the heart by 48% [1]. Several studies have developed methods to assess treatment accuracy by extracting the chest wall (CW) from transit EPID images during DIBH [2,3]. While these methods are useful, they cannot be applied for IMRT or VMAT, which require higher geometric accuracy compared to 3D conformal therapy. Anatomy verification for these sites is challenging due to gantry rotation and obstruction by the MLC.

AIM

- ✓ To develop and test a system to monitor DIBH during whole breast radiotherapy using real-time EPID imaging for IMRT and VMAT.
- ✓ To apply this method retrospectively to EPID images acquired during treatment of 12 left-sided breast cancer patients receiving DIBH radiotherapy.
- ✓ To determine if real time monitoring would improve treatment accuracy for this patient cohort.

METHOD

- Treatment accuracy was assessed by automatically extracting anatomical features from transit EPID images frames at ~8 frames-per-second.
- A method was first developed and tested for tangential IMRT, where the CW contour was extracted from each EPID image frame and compared to the CW contour from the planning CT.
- When the CW was obstructed by the MLC, the breast edge (BE) contour was used to predict the CW using a correlation model.
- This method was tested offline for 12 IMRT patients (147 fractions and 47,000 image frames) treated with DIBH and gated using the Varian RPM system.
- The techniques have been adapted and tested for a VMAT breast treatment, where there is additional obstruction by the MLC and gantry rotation.

RESULTS

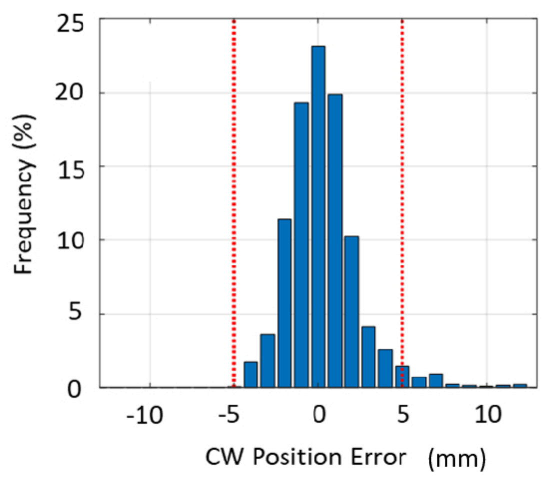

Figure 1: Distribution of measured errors in CW translation compared to projected contours from treatment planning CT for all 12 IMRT patients.

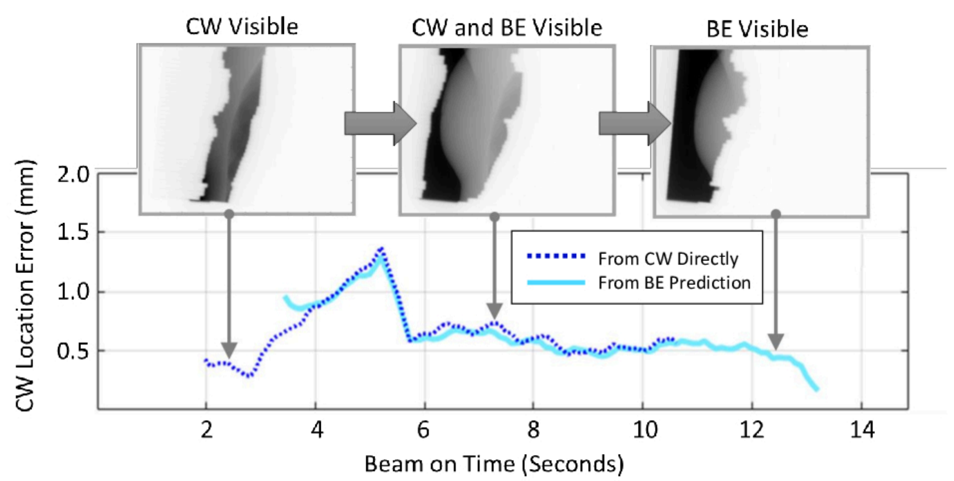

Figure 2: Example of measured CW location errors during an IMRT beam with example EPID images. The dashed line corresponds CW location measured directly from image frames and the solid line corresponds to the CW that is predicted by the BE location.

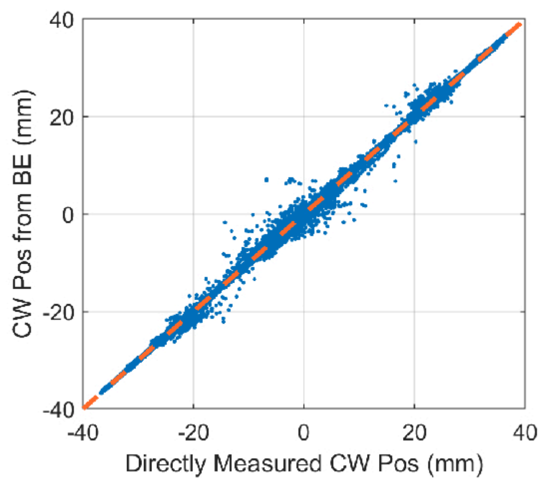

Figure 3: Relationship between directly measured CW and BE-predicted CW. Using this correlation 95% of BE-predicted points were within 0.3 mm of the true CW. This allowed the CW to be monitored 72% of the delivery time compared to 42% if only direct CW measurement was used.

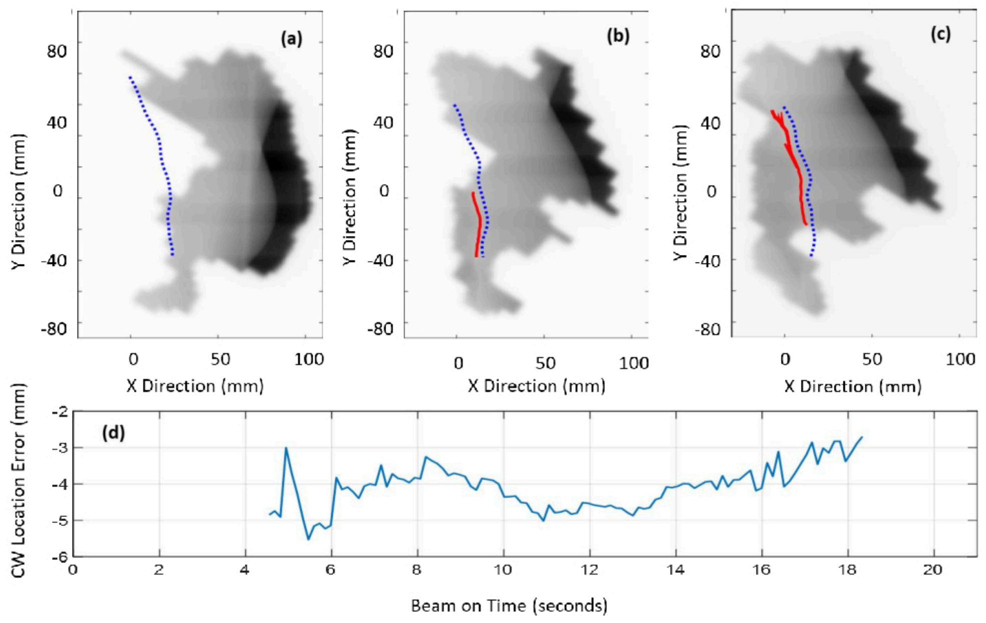

Figure 4: (a-c) Examples of EPID image frames with superimposed planning CW contour and the EPID-measured CW during VMAT. (d) Example of measured CW positional error (mean translation between planned and measured CW) during a VMAT arc.

RESULTS

The mean and standard deviation of errors was 0.2±2 mm for CW position. Of the 12 patients in this study, three patients were identified with less than acceptable accuracy with the CW measured to be > ±5 mm from planned position > 5% of the time during treatment. For VMAT, a portion of the CW was unobstructed by the MLC in the EPID images for 69% of the treatment. The mean and standard deviation of CW error for the one VMAT fraction analyzed was 4.1±1.0 mm.

CONCLUSIONS

A system has been developed and tested to assess the accuracy of DIBH breast radiotherapy for IMRT and VMAT using EPID imaging. The methods have been tested offline and demonstrate that real-time monitoring was required for 25% of patients in this small cohort. Current work is being undertaken to translate these methods into a real-time monitoring system.

ACKNOWLEDGEMENTS

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