Stereoscopic radiographic image guidance and thermo-optical surface guidance for breast radiotherapy in DIBH

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Introduction

The deep inspiration breath hold (DIBH) manoeuvre for breast cancer radiotherapy requires accurate and reproducible patient positioning and motion monitoring. The novel ExacTrac Dynamic 1.1 (ETD) positioning system (Brainlab AG, Munich) combines thermo-optical surface imaging (SGRT) with in-room-based stereoscopic X-ray IGRT and was recently released with a dedicated breast DIBH workflow. Portal imaging (EPID) and cone-beam CT (CBCT) are well established modalities for breast IGRT, but the performance of stereoscopic X-rays in this setting is unknown. The IGRT data of the first breast DIBH treatments on the ETD system was retrospectively analyzed.

Materials and Methods

For left-sided patients with breast cancer two planning CTs were acquired: one in free-breathing (FB) and one CT in DIBH. The surface contours of both CTs were extracted to derive the inspiration breathing amplitude and a 5 mm breathing window was added. Treatments were prescribed as whole breast radiotherapy (40 Gy in 15 fx) with a sequential boost to the tumor bed (10 Gy in 4 fx) and were delivered by 3DCRT, IMRT, or VMAT. Before each fraction, patients were pre-positioned based on the FB surface information. Once the visually guided DIBH was reached two stereoscopic X-ray images were acquired and registered to the left-sided ribs on digitally reconstructed radiographs (DRR) derived from the DIBH CT. Based on the registration a 6 DOF couch correction was performed to position the patient. Positioning and monitoring by ETD was verified by established EPID or CBCT imaging at selected fractions. Residual geometric deviations detected by EPID/CBCT verification imaging were analyzed but not corrected for.

Results

Five DIBH breast patients were treated in 80 fractions using ETD for SGRT+IGRT. The mean X-ray derived couch correction vector from FB to DIBH position was 6.1±3.4 mm. Verification imaging was performed for 25 fractions (39 RT field verifications) with EPID and for 21 fractions with CBCT, respectively. The mean 2D/3D deviation vector length over all verification images was 2.7±1.5 mm / 3.3±1.6 mm for EPID/CBCT (see Figure 1), both measured well within the PTV margins (7 mm). Surface monitoring using the single-camera setup showed a good correlation to the x-ray position in the same breathing status, namely DIBH, but was challenging for larger patients and low breast board inclination.

Discussion

DIBH treatments with the new ETD system were feasible. Surface-based pre-positioning in FB had to be corrected by large couch shifts after stereoscopic IGRT in DIBH. ETD X-ray positioning was successfully verified by standard IGRT techniques. The cause of residual deviations – systematic differences between the imaging modalities or the limited reproducibility of the DIBH manoeuvre – remains subject for further investigations.

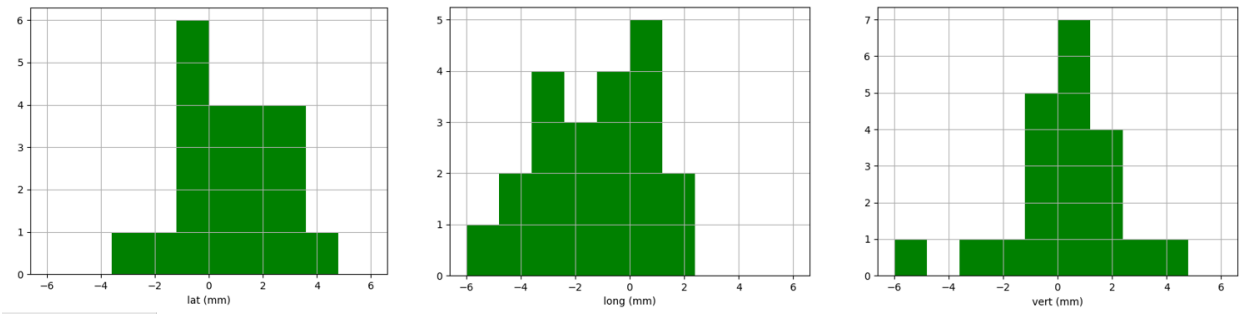

Figure 1: Histograms of residual deviations in CBCT after positioning based on stereoscopic X-rays in 21 fractions