

Purpose: To validate that 4D cone beam CT using the Prior Image Constrained Compressed Sensing (PICCS) method enables accurate extraction of tumor motion profiles using a 1-minute data acquisition scheme.

Methods: Two methods with known ground truth were used in this validation study. The first method is numerical simulations based on a 4DCT dataset of a human subject, and the second one is a physical motion phantom. In both cases, 600 projections were either simulated from human subject 4DCT data or experimentally acquired using a on-board CBCT system (Trilogy, Varian Medical Systems, Palo Alto, California) over a 1-minute gantry rotation through 360°. Images were reconstructed using the PICCS algorithm for all respiratory phases. The motion profile of a selected ROI was extracted using a free-form deformable registration method. The extracted motion trajectories were compared with the ground truth (the first method uses the motion trajectory from 4DCT images, and the second uses the programmed motion profile) for both methods to evaluate their accuracy. The root mean square error (RMSE) was used to quantify the error of motion trajectory over all phase bins.

Results: Results from both methods show excellent agreement between the extracted motion profiles from PICCS-4DCBCT images and the ground truth. The RMSEs for the first method are 0.68 mm, 0.23 mm and 0.24 mm in x, y and z directions, respectively. The RMSEs for the second method are 0.58 mm and 0.47 mm in AP and SI directions, respectively. The accuracy of motion delineation is at sub-pixel level.

Conclusions: PICCS-4DCBCT using a standard 1 minute acquisition protocol has been validated to provide tumor motion delineation with high accuracy.