Purpose:

Undersampling artifacts are a major problem in four-dimensional cone-beam computed tomography (4D-CBCT) and may compromise evaluation of target motion. The role of the target characteristics in scan parameter selection has not been previously investigated. In this work, we evaluated 4D-CBCT performance by assessing the accuracy of target motion measurements for various target sizes and motions. The results may serve as patient-specific guidelines for selection of scan parameters in 4D-CBCT.

Methods:

We acquired 4D-CBCT scans of a moving phantom consisting of six water-filled sphere targets of sizes 10 to 37 mm, with various scan times ranging from 30 sec to 3 min. Two different (3-sec and 6-sec) periods of motions were tested. We used automatic image registration to extract the target motion trajectories and evaluated the accuracy of the measurement for the various target sizes and motions for various combinations of scan parameters.

Results:

The most important object parameter to 4D-CBCT performance was the period of motion. Measurements for the 6-sec motion were always systematically less accurate than measurements for the 3-sec motion for 34 of 36 target sizes/motions for any given scan time. For any given target size, a 45-sec scan for the 3-sec motion yielded nearly equivalent accuracy to a 3-min scan for a 6-sec motion. The second most important parameter was the target size. A 1-min scan was needed for sub-mm motion measurement accuracy of 28-mm target, whereas a 1.5-min scan was needed for the 22-mm target. For all sizes and motions, temporal blurring was observed when the number of phases was fewer than 8.

Conclusions:

Scan time should be set according to target size and motion. We have provided figures that provide the minimum scan time needed to achieve the particular motion measurement accuracy for a particular size and period of motion.