Purpose: Four-dimensional (4D) imaging in the radiotherapy treatment room can provide verification of moving targets, which allows for potential reduction of margins and consequent dose escalation. 4D-CBCT acquisition requires correlation between projections and respiratory phase. Currently, this is achieved with external surrogate measures of respiration, but studies have shown that uncertainties exist in these measures. Therefore, this work aims to develop a markerless self-sorted 4D-CBCT technique.

Methods: The proposed technique identifies projections corresponding to peak inspiration by employing the Fourier Transform (FT) of each projection, from which the magnitude information is extracted. The magnitude from the same low-frequency location for each projection is then plotted, resulting in a repetitive sinusoidal curve. Local minima of this curve correlate to peak inspiration and thus the corresponding projection indices were recorded. This technique was tested on slow-gantry phantom and patient CBCT projections. Projections corresponding to peak inspiration were also visually identified and the average difference in phase (0-100%) was calculated between methods. Selection of different regions of the projection was also investigated in order to find which resulted in the smallest differences. 4D-CBCT cine images were reconstructed for both methods and five physicist observers with extensive 4D-imaging experience were asked to rate any visual differences in motion.

Results: The region of the projection found to be most optimal always directly encompassed an area surrounding the motion. The average differences in phase for the phantom with 3 and 6 second respiratory cycles were 3.10% and 2.00%, respectively. For the three patients studied, these averages were 2.06%, 2.09%, and 8.92%. All observers rated the cine images generated by the two techniques as indistinguishable from each other.

Conclusions: This technique is feasible for the markerless extraction of respiratory phase directly from projections for 4D-CBCT reconstruction.