Purpose: Applicability of the AlignRT surface imaging system was extensively investigated for real-time motion tracking in radiation therapy of lung cancer.

Methods: A 4D computer-controlled motion phantom was employed to simulate a human breathing motion. An anthropomorphic thoracic phantom (a coronal cross-sectional area: ~1,200 cm²) was monitored during the 4D motion tracking. A breathing cycle from a healthy subject (breathing frequency: 0.2 Hz; maximum amplitude: vertical 7 mm, longitudinal 6 mm, and lateral 1.2 mm) was monitored and fed into the phantom control system. The real time monitoring was investigated by modifying a region of detection (the whole, a half, and a quarter of the area) and combination of 3 cameras (patient left, middle, and right).

Results: The real-time tracking errors (detected breathing motion - the input of the subject's breathing) of the phantom motion using one camera (lateral, longitudinal, vertical) were (0.02±0.14 mm, -0.23±0.48 mm, -0.10±0.48 mm) with ipsilateral halves of the area (frame rate: 1.52 Hz), (0.06±0.10 mm, -0.30±0.30 mm, -0.03±0.35 mm) with ipsilateral quarters (frame rate: 1.95 Hz), and (0.19±0.96 mm, 0.29±1.50 mm, -0.46±1.58 mm) with contralateral quarters (frame rate: 3.04 Hz). The detection errors using 2-camera combinations (left-middle and right-middle) were (-0.06±0.06 mm, -0.43±0.21 mm, 0.00±0.22 mm) for the ipsilateral quarters and (-0.62±0.18 mm, -1.20±0.37 mm, 0.03±0.30 mm) for the contralateral quarters, respectively. The 3-camera tracking using halves of the area presented an error of (-0.04±0.12 mm, -0.69±0.35 mm, -0.08±0.38 mm) with a frame rate of 0.62 Hz.

Conclusions: To guarantee a sub-millimeter accuracy of real-time motion tracking in the lung treatment, combination of 2 cameras or less, a frame rate of greater than the Nyquist frequency (in this study fN = 2B (breathing frequency) = 0.4 Hz), and a tracking area of less than an ipsilateral half of thoracic area is highly recommended.