Purpose: To quantify lung planning target volume (PTV) inaccuracies due to motion in non-gated and gated CT images.

Method and Materials: A motorized test object: sphere diameter (2.5, 5.0 cm), orbit diameter (1, 2 cm) and period (3-5 sec.) was constructed. For non-gated helical CT, pitch, slice width, interval and acquisition time was varied. For gated CT, phase and slice acquisition time was varied. Structures were automatically contoured and a 1 cm margin added using a 3D growing tool. A performance metric, normalized volume (NV), was defined as measured PTV divided by theoretical volume (NV=1, static conditions). A uniform margin, based on a spherical model, was calculated over a range of orbital speeds. External marker motion for ten lung cancer patients was measured and minimum residual motion was calculated for a duty cycle spanning CT slice acquisition time.

Results: Optimal non-gated helical protocols (time: 1.0 sec./rotation, pitch: 0.4-0.7, width: 2-3 mm, interval: 1 mm) achieved NV>0.85 over a range of clinically relevant orbital speeds; a standard protocol for lung (time: 1.5 sec./rotation, pitch: 1.5, width/interval: 3 mm) achieved NV>0.70. Gated protocols (time: 1.0 sec./rotation, width/interval 2-3 mm) achieved NV>0.65 over the same range of orbital speeds. For the lung patients, average orbital speed of the external marker ranged from 0.5 to 1.5 cm/sec. and residual motion ranged from 1.5 to 4.6 mm. Assuming a 1:1 ratio of marker to tumor motion, margins for non-gated CT of 0.7 to 1.5 mm (optimal) and 1.5 to 3 mm (standard) were required to achieve NV=1. For gated CT, margins of 0.3 to 1 mm were required.

Conclusions: Inaccuracies in PTV delineation due to tumor motion occur in both non-gated and gated CT images. Average orbital speed of an external marker for lung patients may be used to estimate tumor motion margin.