AbstractID: 6614 Title: A Novel Deformable Lung Phantom for 4D Radiotherapy Verification

Purpose: To develop a reproducible, tissue equivalent, deformable lung phantom for verification of 4D-CT scanning procedures, deformable image registration (DIR) and 4D dose calculation in moving/deformable anatomies.

Methods and Materials: The phantom consists of a Lucite cylinder filled with water containing a latex balloon filled with dampened natural sponges. The balloon is attached to a piston that mimics the human diaphragm. Nylon wires and Lucite beads, emulating vascular and bronchial bifurcations, were glued at various locations, uniformly, throughout the sponges. The phantom is capable of simulating programmed irregular breathing patterns with varying periods and amplitudes. A deformable, tissue equivalent tumour holding radiochromic film was embedded in the sponge. Eight 3D-CT datasets (0.7x0.7x1.25 mm) of the phantom in eight static positions of the piston were acquired. 3D trajectories of 12 anatomical point landmarks as well as the tumour center-of-mass were studied.

Results: Reproducible lung deformation is achieved by piston-provoked pressure changes in water surrounding the deforming balloon. The resulting mean density for the artificial lung was 0.243 g/cm^3 comparable to 0.252 g/cm^3 for a real lung. A truly 3D, non-isotropic deformation of the balloon similar to a real lung has been obtained. The SI displacement of the landmarks varies between 94% and 3% of the diaphragm excursion for positions closer and farther away from the diaphragm, respectively. Reproducibility in the deformed phantom, established by seven repeat scans at the same phantom compression state, was within image resolution. The accuracy of DIR of the extreme phases was 0.7($\pm$0.7) mm.

Conclusions: Our novel phantom is tissue-equivalent, deformable, and can reproducibly emulate 3D non-isotropic lung deformations. The presence of vascular and bronchial bifurcations allows verification of DIR of 4D-CT images of the phantom. Registered phases of the phantom can be used in 4D dose calculations that can be validated by comparison with dose measurements.