4D dynamic Arc of non-modulated variable-dose-rate fields for Lung SBRT: A feasibility study

**Motivation:** To finish the treatment while correlation between the breathing surrogate and the tumor is maintained is of importance for SBRT especially for 4D delivery. Conformal plans with around 10 beams of static gantry angles for lung SBRT produce clinically acceptable plan quality. Beam modulation is not necessary for the most of the cases of SBRT cases since small fields. Significant effects of the reducing time and the reducing target margin are expected if converting these beams into a dynamic arc and combining 4D components, *i.e.*, motion tracking dynamic MLC. This study is to test this hypothesis.

**Methods:**
- **Initial Plan:** 3D conformal plan with P0 phase of 4DCT. Static Gantry angle
- **Conversion to Dynamic Arc:** Gantry angle of 0.3 deg is assigned to each breathing phase (0.4 sec when a period is 4sec). This gantry speed, 22.2 MU/ deg with 1000 MU/ min, guarantees the delivery of the maximum dose rate. Then the arc angle for a beam is determined from the planned monitor units (example, 4.6 deg when 100 MU at 1000 mu/min dose rate). Maximum gantry rotation speed (4.8 deg/ sec) is assigned when beam is off. All the beams are combined into an arc or two arcs of VMAT mode.
- **4D Plan:** Each segment is divided into 0.3 deg and new aperture is assigned to the divided segment. Transformation vectors of the target from a reference phase to each of other phases are derived using segment aperture morphing (SAM) [1]. Dose calculation was performed for each segment and the composite plan was acquired using a commercially available deformable image registration tool.

**Discussions:** 4D delivery plan was delivered without creating errors. Since the limitation of number of control points of VMAT mode of Varian linear accelerators, single arc plan is limited to less than 1400 MU. Any plans with more than 1400 total MUs are needed to split into two or more partial arc beams. Delivery time for typical SBRT lung plans are less than 2.5 min, either single full arc or two partial arcs. Total delivery time from beam on to beam off matches well to that of calculation. Time matching is very crucial for 4D delivery, compensation of tumor motion using dynamic MLC is guaranteed only when matches. Further studies are needed: (1) Control point by control point evaluation of temporal matching, (2) dosimetrical effect of beam rising time of beginning of each segment module.