Evaluating Gantry Sag on Linear Accelerators and Introducing an MLC-Based Compensation Strategy

Novelty and Impact: A simple and precise method was introduced to quantify the sub-millimeter gantry sag on linear accelerators, using a ball-bearing phantom and the electronic portal imaging device (EPID). The gantry sag was found to be small, reproducible, and varying with gantry angle. An MLC-based strategy to compensate for gantry sag was proposed.

Three Varian linacs were used in this study: linac A (Clinac 21EX), linac B (Clinac iX), and linac C (Trilogy). For each linac, a ball-bearing phantom was placed near the isocenter using room lasers. The center of the ball bearing served as a reference point (not necessarily at the isocenter) (1,2). An MLC-shaped 10×10 cm² field was used to image the ball bearing at 10° gantry angle intervals. The radiation field center (RFC) and the ball bearing were detected in each acquired EPID image. The radiation isocenter was localized at the intersection of all RFCs. Then, the gantry sag was computed as the radial distance from the radiation isocenter to each RFC. This measurement was performed at 0° and 90° collimator angles to study the effect of collimator position accuracy on gantry sag. We also investigated a strategy to reduce the gantry sag by rotating the MLC to 90° and offsetting the MLC leaves. The amount of MLC leaf offset was the opposite of measured gantry sag, which was gantry angle-specific.

The measured gantry sag was reproducible on linac A over a 6-month period (Figure 1). The RFC moved in the inferior direction (away from the gantry) as the gantry was rotated from 0° to 180°. The gantry sag was approximately sinusoidal in shape and had similar magnitudes across the 3 linacs (Figure 2), indicating the consistency of mechanical characteristics from the same manufacturer. At 0° collimator angle, the maximum gantry sag was 0.77 mm (linac A), 0.99 mm (linac B), and 0.89 mm (linac C). At 90° collimator angle, the maximum gantry sag was 0.79 mm (linac A), 0.83 mm (linac B), and 0.71 mm (linac C). The leaf position uncertainty did not increase the gantry sag measured at 90° collimator angle, compared with that at 0° collimator angle. After the MLC leaf offsets were applied at 90° collimator angle, the maximum gantry sag was reduced to 0.18 mm (linac A), 0.18 mm (linac B), and 0.14 mm (linac C) (Figure 3).

In summary, linac gantry sag was quantified with sub-millimeter precision. The maximal gantry sag ranged from 0.7 mm to 1.0 mm on the 3 linacs in this study. Compensation for gantry sag was feasible by offsetting the MLC leaves at 90° collimator angle.

References: