Comprehensive evaluation of EPID image acquisition for integrating and temporal dosimetry of fixed-gantry IMRT and arcIMRT

Purpose: To evaluate EPID for dosimetry applications of arc and static-gantry IMRT with sliding window (SW) and/or step and shoot (SS) deliveries and to determine operating conditions under which EPID can be used accurately for integrating and temporal dosimetry.

Methods: IMRT beams (SW & SS) were designed that generate beam hold-offs and dose rate modulation due to MLC motion under 10 x 10 cm jaw. An arcIMRT beam was designed by adding gantry movement to the SW field. A 10 cm x 10 cm open beam was also used. See Fig. 1. Despite differences in pulse/dose rates, the four beams should deliver the same total dose. For each beam, various MUs with 6 MV beam at 300MU/min were irradiated on EPID which operated in image acquisition of integration mode (IM), continuous scanning mode with synchronization (CMs) and without (CMn) to beam pulses. Temporal ion chamber measurement was performed to dosimetrically validate CMs images. Acquired images were evaluated in repeatability, dose linearity, and reproducibility (reproduce open beam output in IM). (Purpose ends. Results below.)

Results: In IM, repeatability, dose linearity, and reproducibility were within 1% for all dose levels and beams. In CMs, they were within 1-2% if dose rate was maintained steady for SW beam (needed a minimum 1.3 MU/cm MLC motion) and arcIMRT beam (needed a minimum 1 MU/degree and 2.8 MU/cm MLC motion) and if a minimum of 38-40 MU per shoot was used for the SS beam (relative duration of irradiation than travel time). But a serious nonlinearity was observed for fewer MUs. This is due to the response of EPID to pulse-length reduction for fixed-gantry therapy and pulse dropping for arc therapy. The latter produces in-planar non-uniformity making EPID unsuitable for temporal dosimetry of arcIMRT (Fig 2), although acceptable for that of fixed-gantry IMRT. Sacrifice in temporal resolution then became necessary such as multi-frames/image, which provided acceptable non-uniformity. Figures 3 & 4 validate dosimetrically EPID signal after temporal resolution reduction to 1sec/image (reduced dose fluctuation due to non-uniformity, EPID matching IC). CMn results were similar to those of CMs, but due to artifacts, this mode was not preferred.

Conclusion: We found conditions under which integrating and temporal EPID dosimetry can be used for IMRT and arcIMRT dose deliveries.