EPID Dosimetry in Intensity Modulated Radiation Therapy Applications

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Preface

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Abstract

Electronic Portal Imaging Devices (EPIDs) can be used for dosimetric purposes, provided that an appropriate dosimetric calibration is used. However, in most studies published so far, transmitted dose maps, measured using EPIDs, are used under limited conditions only and further investigation is required for more complex conditions.

In order to use a Scanning Liquid Ionization Chamber (SLIC)-EPID as a comprehensive two-dimensional dosimeter, a calibration method was developed in the current work. This includes investigation of the following issues: additional build-up layer on the EPID; relationship between Electronic Portal Images (EPIs) pixel values and dose on the beam central axis; variation in the measured dose with the radiation field size; SLIC-EPID response with gantry rotation; variation of EPIs with the acquisition time lag; and the reconstruction of the beam horns in off-axis areas using KODAK Extended Dose Range (EDR2) films.

In order to verify the calibration method, the radiation fluence maps measured using a SLIC-EPID were compared with EDR2 film measurements for open and wedged fields using the gamma function algorithm with Distance To Agreement (DTA) and Dose Difference (ΔD_{max}) of 2.54 mm and 1%, respectively. The SLIC-EPID relative dose measurements for a range of homogeneous and inhomogeneous phantoms were also compared to EDR2 film and *Pinnacle*^{3} Treatment Planning System (TPS) data sets.

Prior to using SLIC-EPID for complex treatment modalities, an investigation was carried out on the following: evaluating the SLIC-EPID to detect the minimum change in phantom/patient thickness; an evaluation of SLIC-EPID sensitivity to detect the phantom/patient positioning uncertainties and their effect on the transmitted dose maps; dosimetric characteristics of various radiation field set-ups such as the comparison of Multileaf Collimator (MLC) fields with conventional radiation fields; and evaluating MLC leaf positioning using a SLIC-EPID. Finally, SLIC-EPID response was assessed for segmented Intensity Modulated Radiation Therapy (sIMRT) applied to prostate, and head and neck cases. The results were compared to those that planned using Pinnacle^3

TPS calculation using the gamma function algorithm with DTA and ΔD_{max} of 2.54 mm and 3%, respectively.

For open and wedged fields (in air), the gamma scores for SLIC-EPID and EDR2 film measurements were found to be greater than 95% with 1%/2.54 mm (two pixels). For both homogenous and inhomogeneous phantoms, more than 90% agreement was achieved using gamma criteria of 2%/2.54 mm and 3%/2.54 mm, respectively.

The results showed that a 6 mm change in phantom/patient thickness of a homogeneous phantom can be detected using a transmitted dose measured by the SLIC-EPID. It was also found that SLIC-EPID can detect 1-2 mm patient positioning uncertainties. For radiation field set-up using conventional collimators and MLCs, a significant difference in the penumbra width and radiation field size was observed. A linear relationship was observed between relative dose difference and MLC leaf spatial displacement. The minimum detectable MLC leaf displacement was approximately 0.1 mm using standard edge detection algorithms.

For sIMRT prostate and head and neck cases, a good agreement ($\geq$ 92%) was found between measured and calculated transmitted dose maps for each subfield and the total field in the A-P direction. For non-zero gantry positions the discrepancies increase due to radiation beam absorption in the treatment couch. Several inconsistencies were also observed for small radiation fields.

It can be concluded that SLIC-EPID is a sensitive device for dose delivery verification in three-dimensional Conformal Radiation Therapy (CRT) and segmented Intensity Modulated radiation Therapy (sIMRT) as well as for Quality Assurance (QA) of the dosimetric characteristics of MLC fields. The radiation beam attenuation of the treatment couch for oblique beams and SLIC-EPID response for small radiation fields (less than 3×3 cm^2) should be considered as the main limitation in using SLIC-EPID for comprehensive dose delivery verification. In conclusion, SLIC-EPID can be used as a two dimensional dosimeter for complex treatment conditions when an appropriate dosimetric calibration is applied. It can also be used for regular QA of MLC fields.