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Original research article

A calibration method for patient specific IMRT QA using a single therapy verification film

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ABSTRACT

Aim: The aim of the present study is to develop and verify the single film calibration procedure used in intensity-modulated radiation therapy (IMRT) quality assurance.

Background: Radiographic films have been regularly used in routine commissioning of treatment modalities and verification of treatment planning system (TPS). The radiation dosimetery based on radiographic films has ability to give absolute two-dimension dose distribution and prefer for the IMRT quality assurance. However, the single therapy verification film gives a quick and significant reliable method for IMRT verification.

Materials and methods: A single extended dose rate (EDR 2) film was used to generate the sensitometric curve of film optical density and radiation dose. EDR 2 film was exposed with nine 6 cm × 6 cm fields of 6 MV photon beam obtained from a medical linear accelerator at 5-cm depth in solid water phantom. The nine regions of single film were exposed with radiation doses raging from 10 to 362 cGy. The actual dose measurements inside the field regions were performed using 0.6 cm^3 ionization chamber. The exposed film was processed after irradiation using a VIDAR film scanner and the value of optical density was noted for each region. Ten IMRT plans of head and neck carcinoma were used for verification using a dynamic IMRT technique, and evaluated using the gamma index method with TPS calculated dose distribution.

Results: Sensitometric curve has been generated using a single film exposed at nine field region to check quantitative dose verifications of IMRT treatments. The radiation scattered factor was observed to decrease exponentially with the increase in the distance from the centre of each field region. The IMRT plans based on calibration curve were verified using the gamma index method and found to be within acceptable criteria.

Conclusion: The single film method proved to be superior to the traditional calibration method and produce fast daily film calibration for highly accurate IMRT verification.

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1. Background

Intensity-modulated radiotherapy (IMRT) is a highly conformal treatment modality that requires precise dose verification. Due to the increased complexity of IMRT as compared to conventional radiotherapy, various experimental studies related to IMRT dosimetry have been performed.[1–7] The interest in film dosimetry for IMRT quality assurance is due to its ability to give precise two-dimensional absolute dose distributions having spatial resolution in the sub-mill metric range. The uses of radiographic films for IMRT dose verification require a quick and reliable method to generate an accurate dose response curve.[8–11] This reliability depends on a number of contributing errors viz., variations of film manufacturers, day to day variation in processing conditions and energy dependence of radiographic films. Errors due to film-to-film variation and geometrical conditions for film exposure can affect the calibration curve while using multiple films for different doses to generate a single sensitometric curve. In the case of multiple films, the error due to film storage, exposure conditions, film developer and scanner variation can be reduced by generating a calibration curve each day, rather than relying on old calibration curve. Such calibration techniques are at best inefficient, consuming as many as 15 films to generate a film sensitometric curve, and at worst unsuitable for exposure geometry.

On the other hand, the use of a single film can eliminate errors due to film to film variation and scattering response for low energy photons. The advantages of the single film calibration are exposure simplicity, time saving and minimum use of radiographic resources with improved processor quality control. Potential limitations of using single films are over response of film due to low energy photons originating from the penumbra region or edge of MLC treatments fields and significant scatter components resulting from all neighbouring fields. The over response of film with low energy photon can be minimized by using scattering filters and the use of high dose films.[12,13] The use of scatter filtering creates an additional unwanted component resulting from the Compton scattering of high energy photon, which can still expose the film. Response variations of a radiographic film under different exposure conditions are well known.[14] The high dose films are less sensitive to low energy photons and contain less silver halide crystals as compared to low dose films. The reduced effective Z lowers the photoelectric attenuation coefficient of a film; as a result the film responds to photons in a manner similar to tissue. EDR 2 high dose radiographic film has been established an accurate 2D dosimeter for IMRT QA, commissioning of treatment modalities and verification of treatment planning system (TPS).[15–18] The present work reports verification of the commission of patient specific intensity-modulated radiation therapy (IMRT) using a fast and efficient single film calibration method without any scatter filtering. We also investigate the contribution of scatter radiation to primary dose and scatter component on each field region. The present study is to introduce a fast calibration method to measure sensitometric curve using a single radiographic film and its verification in patient specific intensity-modulated radiation therapy (IMRT) quality assurance.

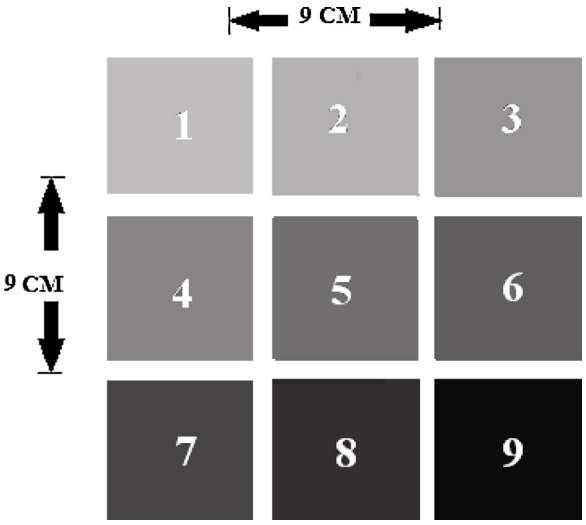

Fig. 1 – Field arrangement for EDR 2 film irradiation and scatter dose measurement.

2. Aim

Aim of the present study is to introduce a fast calibration method to measure sensitometric curve using a single radiographic film for patient specific intensity-modulated radiation therapy (IMRT) quality assurance.

3. Materials and methods

3.1. *Irradiation of EDR2 film*

A single extended dose rate (EDR 2, Radiation Products Design, Inc.) film was used to generate the sensitometric curve. All the nine fields of 6 cm × 6 cm field size with its centre were marked on the envelope of the ready pack EDR 2 film as well as on a white paper with the help of optical field. The centre to centre distance between fields in lateral and perpendicular direction was 9 cm and the distance between two adjacent fields was 3 cm (Fig. 1). The film was kept at 5 cm depth in solid water slab phantom SP34 (Gammex Inc., Middleton, WI) perpendicular to the central axis of the beam with the source to surface distance (SSD) of 100 cm and the paper was fixed on the surface. 10 cm extra margin of solid phantom are placed beneath the depth of dose measurement to provide sufficient backscatter factor. The film was exposed with 9 fields of 6 MV photon beam of Clinac DBX linear accelerator equipped with 80-leaf millennium MLC (Varian Medical System, Palo Alto, USA) using field size of 6 cm × 6 cm with the lateral and longitudinal movement of the treatment couch. The dose range covered by a calibration film was chosen to encompass the dose range typically used with clinical IMRT treatment fields. The doses delivered to each region of the EDR 2 film ranged from 7 to 380 Monitor Units (MU) which corresponds to 10–362 cGy, respectively.