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Experimental Validation of Treatment Planning for Multiple Radiotherapy Fields by EDR2 Film Dosimeter

Vahid Fayaz , Asieh Tavakol

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***Abstract*—**To investigate the applicability of the EDR-2 film for clinical radiation dosimetry, percentage depth-doses, profiles and distributions in open and dynamically wedged fields were measured using film and compared with data from a Treatment Planning system.The validity of the EDR2 film to measure dose in a plane parallel to the beam was tested by irradiating 10 cm×10 cm and 4 cm×4 cm fields from a Siemens, primus linac with a 6MV beam and a source-to-surface distance of 100 cm. The film was placed Horizontally between solid water phantom blocks and marked with pin holes at a depth of 10 cm from the incident beam surface. The film measurement results, in absolute dose, were compared with ion chamber measurements using a Welhoffer scanning water tank system and Treatment Planning system. Our results indicate a maximum underestimate of calculated dose of 8 % with Treatment Planning system.

***Keywords*—**6MV Photon , EDR-2 film, Radiotherapy, Treatment Planning system

I. Introduction

UNTIL quite recently, film has been the traditional way of verifying patient position. In this section, the physical aspects of film used for patient setup verification are reviewed.The difficulties encountered when using film are also addressed. Radiographic films normally have light-sensitive emulsion coated on both sides. In treatment positioning verification, the film is normally sandwiched between two metal or fluorescent screens [1].Radiation therapy dosimetric studies using radiographic film have been performed since the introduction of cobalt-60 teletherapy and high energy betatrons for clinical use[2]. The advantages of film over other measurement techniques includespeed of data collection, low cost, improved spatial resolution, and simultaneous integration of dose at all data points. Film is potentially the ideal detector for determining dose distributions for dynamic beams and for studying combinations of stationary beams treated sequentially (e.g. gap dosimetry)[3].Both of these situations are difficult to measure using conventional water phantom dosimetry systems, since the dose distribution changes with time.Although film dosimetry is frequently used to determine relative dose distribution for electron beam therapy, measurement of dose distribution for photon beam therapy is not widely accepted. This low level of acceptance is a result of the fact that the film sensitivity varies as the distribution ofphoton energies shifts within a tissue equivalent phantomwith field size and depth[4]. Relative to ion chamber measurements, differences of 30% or more in percentage depth dose values have been observed for a cobalt-60 10 cm×10 cm field at depths greater than 15 cm[5]. Differences up to 5% for 25 MV accelerator beams have been reported[6].

Vahid Fayaz is with Department of Physics , Hamedan branch , Islamic Azad University (corresponding author to provide phone: +989127070053; e-mail : fayaz_vahid@yahoo.com).

Asieh Tavakol is with the Research Group Of Hamedan Mehdieh Charitable, Medical Diagnostic Imaging Therapeutic Center, Hamadan Iran (corresponding author to provide phone: +989127070052; e-mail: Asieh_tavakol@ yahoo.com).

II. Materials and Methods

All measurements were performed using a Primus linac (Siemens, Germany) established in the Mahdieh Radiotherapy and Oncology, Hamadan, Iran. The primus linac provides two low and high energy photon beams (6 and 15 MV) and a range of electron beams (5-12 MeV). The original fluence maps were manipulated for several transitional and rotational displacements. The results, as evaluated maps, were then compared with the original fluence maps, as reference maps. All of the current work procedures were performed using in-house codes written by MATLAB.

A. Phantom

A solid water phantom was used for this study (12cm diameter), representative of a neck or breast. The surface 1cm of this phantom was bolus material. Measurement positions were identified on the surface of the phantom using marks and radiopaque fiducials. The phantom was CT scanned, giving CT pixels 1.3mm x 1.3mm x 2.5mm. This is representative of the imaging parameters used in our clinic.



Fig. 2 set up for parallel-plate chamber measurements

B. Treatment planning system calculations

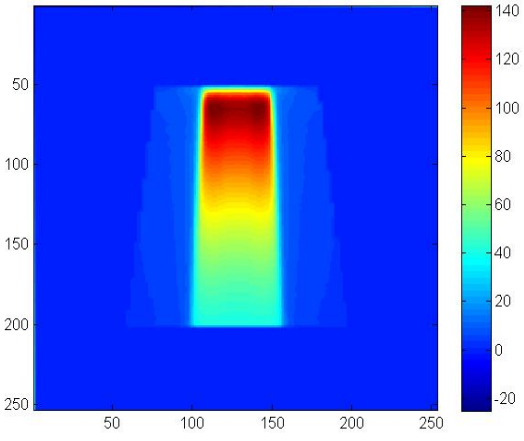
According to ICRP(5) and ICRU(6) reports, the recommended depth for practical dose assessments is 0.07mm. This corresponds approximately to the interface between the epidermis and dermis layers of the skin(4,7) (0.05 – 1.5mm, depending on the anatomic location). This is very difficult to measure, or calculate using most treatment planning systems. For practical reasons, for this work, we therefore chose to define the skin dose as the mean dose to the surface 2mm thick volume in the region of interest. Separate plans were created in COREPLAN for each experimental setup. Skin doses were calculated by first creating a 2mm thick 10mm x 10mm surface structure centered on the measurement mark (as seen using fiducials in the CT images). For the propose of this study, skin dose was calculated as the mean dose to this structure. The dose calculation grid was set to 2.5mm, as this is the size used for most clinical cases . The measured and calculated doses were compared, and the differences were expressed as a percentage of the measured dose.

III. Film Dosimetry Considerations

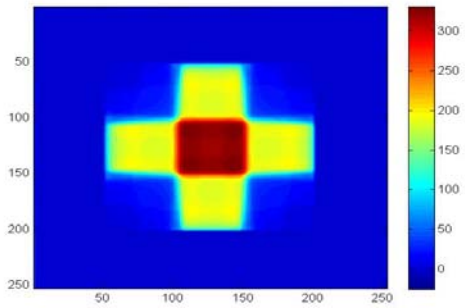
The silver halide of a radiographic film is contained in an emulsion coated on a polyester base and protected by a thin gelatine layer for mechanical integrity. Radiographic films are available in different sizes (e.g. 25.4 cm x 30.5 cm), and their radiation dose range is between several mGy and several Gy. A difficulty with conventional silver-halide radiographic film, such as Kodak X-Omat V, is the increased sensitivity of the film to low energy scattered x-rays. This prevents its routine use as a dosimeter when irradiated in a plane parallel to the incident beam where the scatter contribution increases with depth. EDR2 film (Kodak) has recently been introduced which does not demonstrate the same increased sensitivity to low energy x-rays and has a linearity of dose-response up to about 5 Gy (Olch 2001). We employ ERD2 film to measure absolute dose to a plane for Experimental Validation Of Treatment Planning . We irradiate calibration films to a known dose in a polystyrene phantom at 10 cm depth; the dose at this point is confirmed with a parallel plate ion chamber measurement.Film scanning and dosimetry are performed with a Wellhofer VidiScan system. Calibration films are irradiated approximately every 15 cGy and are used to create a conversion table from the Vidar grey-scale values to dose. The Vidiscan software performs a linear interpolation of intermediate dose values during conversion, and therefore, a high number of calibration films is required for reasonable accuracy.

IV. Result

The results obtained with all three 2-D detector systems were in good agreement with calculations performed with the treatment-planning system and with the standard dosimetric tools, i.e., films or various point dose detectors.



A

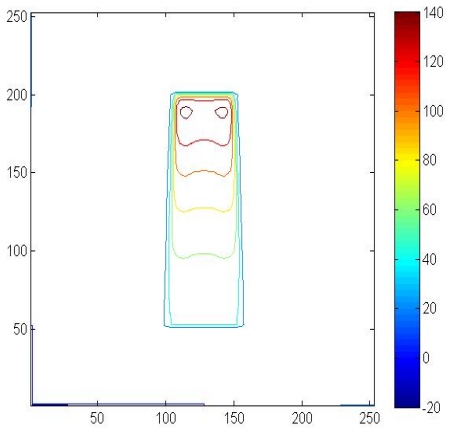


B

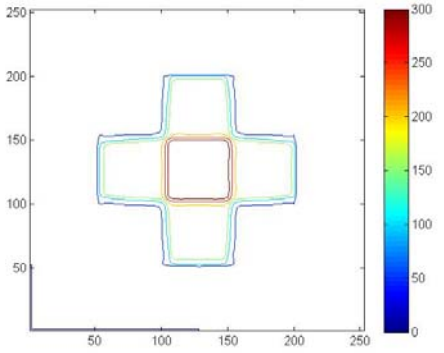
Fig. 1 isodose curves are shown for film as calculated using the Single (A) and Multiple(B) 10 cm ×10 cm calibration film set for density to dose conversion

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A



B

Fig. 2 Isodose contours at central axis of 10×10 cm² beamlets measured with the EDR2 film .The relative isodose contour values ,Single (A) and Multiple(B)

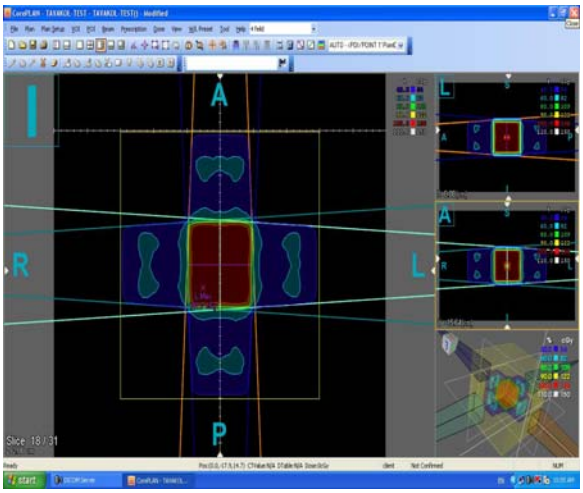


Fig. 3 the screenshot of CorePLAN showing the energy distributions for a phantom (in cGy). There are four X-ray beams aimed to a phantom. The center of the intersection of the beams (the Square red cross) is situated at the cancer mass (delimited by a solid red contour)

V. CONCLUSION:

Film dosimetry is an important tool for the verification of irradiation techniques. The shape of the sensitometric curve depends on the type of film as well as on the irradiation and processing conditions.It was found that Kodak EDR2 film can be used to accurately measure absolute & relative dose in a phantom, particularly in a plane parallel to the beam axis.It could be shown that all three systems offer dosimetric characteristics required for performing field-related Radiotherapy QA with relative dose measurements. Our results indicate a maximum underestimate of calculated dose of 8 % with Treatment Planning system for multiple segment fields and 4% in single fields.

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