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Spatial resolution of a stacked radiochromic film dosimeter

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Abstract

Purpose: The spatial resolution of stacked radiochromic film dosimeters, which have increased sensitivity from a single layer radiochromic film detector, has been studied.

Methods: A 5-layer film which can easily be constructed provided a 4.3-times increase in sensitivity over a single layer film at 670 nm readout wavelength which meant that doses as low as 0.6 Gy could be measured with an accuracy of ±4% with the stacked dosimeter. The spatial resolution was tested by comparison of the 80%/20% penumbral widths of a 5x 5cm 6 MV X-ray field.

Results: The MD-55-2 film measured the penumbral width as 3.0 mm whereas the 5-layer stack dosimeter measured the same penumbra as 3.2 mm.

Conclusion: The stack dosimeter can provide useful in vivo information such as the position of a diverging beam edge for treatments around critical structures such as eyes during the first fraction of treatment.

Keywords: Spatial resolution; Radiochromic film; Stacked dosimeter; Radiotherapy

1. Introduction

In vivo dosimetry forms an integral part of radiotherapy quality assurance and assessment of dose delivered to patients. Devices such as thermoluminescent dosimeters or diode detectors [1] are commonly used for such measurements. However they are limited to point dose measurements due to their physical characteristics. Radiochromic film provides a relatively energy independent medium [2] with high spatial resolution for detection which could be placed in vivo during treatment if required. Its limiting factor, however, is its sensitivity with doses above approximately 3 Gy required to provide accurate dosimetry [4]. To overcome this sensitivity problem, the radiochromic film can be placed in layers to produce a stacked film detector.

2. Materials and methods

To assess the spatial resolution of the film stack dosimeter, a series of 5-layer detectors were constructed from Gafchromic MD-55-2 film, batch no. 970116. To perform this, five 1 × 5-cm strips were tightly bound together with clear sticky tape on top of each other. They were bound this way to minimize any air gaps between the films and to reduce any movement/sliding of the films. The detector thickness was measured as 0.84 ± 0.03 mm. Handling precautions as outlined in TG-55 [4] were used. The stack detectors were then exposed using a double exposure technique. The standard dose given was 1 Gy. Due to the slight non-uniformity of sensitivity response of Gafchromic film [3], this calibration must be performed before use of each detector. Also each detector's response will vary slightly due to the inherent changes in sensitivity of the Gafchromic film used to make up each stack detector. This effect is similar to variations in response for thermoluminescent dosimeters (TLDs) and diodes and can be accounted for using the double-exposure technique. To assess the spatial resolution of the 5-layer film detector in clinical situations, a 6-MV X-ray beam penumbra was measured. A 5 × 5-cm field was measured at 1.5 cm depth at an SSD of 100 cm. For comparison, the same experiment was performed with a single layer MD-55-2 film with an applied dose of 5 Gy. The stack dosimeter was also tested in vivo for use in assessment of the position and quantity of exit dose from a diverging beam edge near an eye. The film was placed in vivo, covering the region which was calculated as the geometrical beam edge for a 6-MV 8.5 × 10.5-cm beam. The applied dose for the beam at D_{max} was calculated as 1.45 Gy. After irradiation the film was analysed for visible verification of the beam edge on the patient and for absolute dose assessment.

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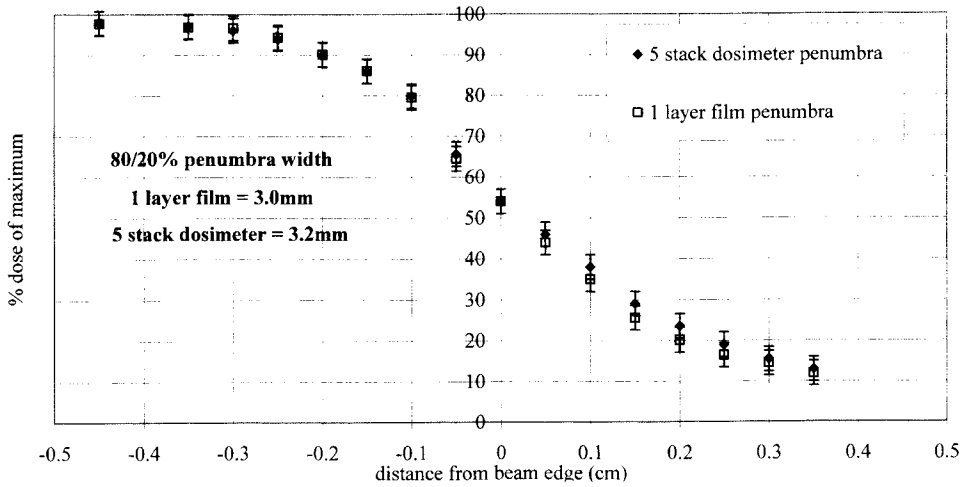

Fig. 1. Penumbral measurement highlighting the minimal change in spatial resolution between a single layer and 5-layer Gafchromic film detector.

3. Results and discussion

Results for spatial resolution tests are shown in Fig. 1. The 20%/80% dose width for the single layer film was found to be 3.0 mm and for the 5-stack dosimeter it was found to be 3.2 mm. Therefore a relatively small decrease in spatial resolution is found by binding the five film layers together to produce the stack dosimeter. As the spatial resolution using the 5-stack dosimeter was still high, the film should be extremely useful for determination of beam edge doses around critical structures such as eyes where exiting beams can diverge into a region where serious effects might occur. Fig. 2 shows results for an in vivo measurement on a patient for assessment of exit dose from a 6-MV X-ray beam. The position of the calculated geometrical edge of the beam is defined as the 0-cm position. For comparison, results for two LiF thermoluminescent dosimeter chips are given at specific sites within the field. Visual inspection of the film which received a measured maximum dose of 0.89 Gy was performed. The visual edge of the beam could be defined with the help of a torch light whilst the film was still positioned on the patient. The torch light was required due to the fact that the film's colour change is not extreme at these doses but variations seemed to be enhanced using an extra light source during visual inspection. This is extremely useful for the radiation oncologist who can therefore assess the field exit position and beam divergence on the patient after one fraction of treatment. The errors shown on the graph are 2 standard deviations of the mean for five separate measurements made on the same patient during a 1-week period. Results for absolute dose below approximately 0.3 Gy varied considerably (as a percentage error) using the technique. However, the film did highlight the position of the beam edge straight after treatment which is not possible with TLDs, diodes or even radiographic film which would need to be developed before analysis.

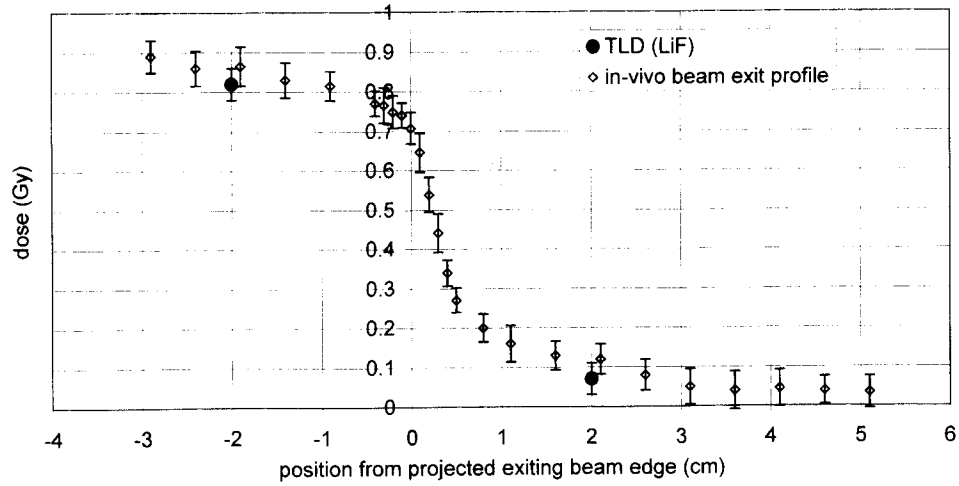

Fig. 2. In vivo measurement using the 5-layer detector on the beam exit side of a treated patient. The film provided an instantaneous visual measure of the beam's edge.

4. Conclusion

The stack dosimeter can provide accurate in vivo dosimetry results within the field on the first fraction of treatment and also provide a relative high level of spatial resolution for detection. This makes the stack dosimeter useful for assessment of dose near beam edges or changes in dose over a region. A 5-layer stack produces a detector which is less than 1 mm thick, and increases its sensitivity by nearly a factor of 5 compared to a single layer film. Thus doses as low as 0.6 Gy could be accurately measured. This lies within most radiotherapy fractionated treatment regimens. The spatial resolution of the stacked dosimeter was not severely diminished as compared to MD-55-2 film. Thus the stacked dosimeter has an advantage over point dosimeters such as TLDs and diodes for determination of dose over a region were high spatial resolution would be required.

Acknowledgements

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References

[1] Kron T, Butson M, Hunt F, Denham J. TLD extrapolation for skin dose determination in vivo. Radiother Oncol 1996;41(2):119–123.
[2] Kron T, Duggan L, Smith T, et al. Dose response of various radiation detectors to synchrotron radiation. Phys Med Biol 1998;43(11):3235–3259.
[3] Meigooni AS, Sanders MF, Ibbott GS, Szeglin SR. Dosimetric characteristics of an improved radiochromic film. Med Phys 1996;23(11):1883–1888.
[4] Niroomand-Rad A, Blackwell C, Coursey B, et al. Radiochromic film dosimetry: recommendation of AAPM radiation therapy task group 55. Med Phys 1998;25(11):2093–2115.