

Application of GAFCHROMIC® EBT film for *in vivo* dosimetry with total body irradiation (TBI) radiotherapy

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Introduction

The GAFCHROMIC® EBT film is a fairly new film product designed for absorbed dose measurements of high-energy photon beams¹⁻². *In vivo* dosimetry for total body irradiation (TBI) remains a challenging task due to the extended source-to-surface distance (SSD), low dose rates, and the use of beam spoilers³. Traditionally, thermoluminescent dosimeters (TLDs) are used to verify the homogeneity of dose throughout the treatment field and to evaluate the doses along the central axis of the patient. However, handling TLDs is labor intensive and requires expensive equipment and dedicated workspace to house it. GAFCHROMIC® EBT films have advantages over conventional dosimetry methods (i.e. TLDs) used for TBI dose validation because they are easy to handle and flexible in shape to fit the patient's body contour. In this work, we evaluate the feasibility of the GAFCHROMIC® EBT film for the dose measurements with the TBI treatment technique. We specifically assessed the accuracy, reproducibility, dose linearity, and *in vivo* performance of the film in TBI irradiation conditions.

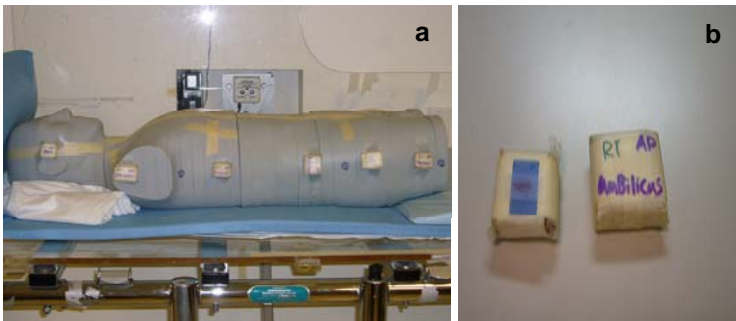


Fig. 1. (a) The anthropomorphic phantom setup. (b) GAFCHROMIC® film piece and TLDs covered with a bolus.

Materials and Methods

Measurements were performed with GAFCHROMIC® EBT film (ISP Corp., Wayne, NJ) samples (2.5 x 1.5 cm² in size) which were cut from the same batch (Lot #: 36306-0021). Net optical densities (NetOD) of the irradiated films were converted to absorbed dose using the calibration procedure described by Devic et al⁴. Absolute doses were determined using the PTW Farmer-type ionization chamber (PTW-Freiburg, Freiburg, Germany) connected to a Keithley 602 Electrometer (Cleveland, OH). Exit doses were evaluated under TBI conditions with the cylindrical phantom. Furthermore, an anthropomorphic phantom (CIRS, Norfolk, VA) was set in the treatment position according to the standard procedure of lateral TBI technique in our institution (Fig.1a). Film pieces and TLDs were covered by bolus (Fig.1b) and were packed together at the location of the pre-defined anatomical locations. GAFCHROMIC® EBT film samples were also used for *in vivo* dose measurements on two TBI patients.

Table 1. Central-axis doses (D (CAX, cGy)) converted from NetOD of GAFCHROMIC® EBT films and doses measured by TLDs (D(TLD, cGy) for six anatomical sites on the anthropomorphic phantom.

Anatomical regions	Separation (cm)	D(CAX, cGy)	Difference % (Film vs. prescription dose)	D(TLD, cGy)	Difference % (TLD vs film)
Head	7.9	101.5	1.46	103.6	-2.02
Shoulder	38.1	100.9	0.93	105.0	-3.83
Chest	30.8	97.8	-2.21	97.3	0.55
Umbilicus	28.4	100.0	0.04	103.3	-3.18
Hip	30.8	97.4	-2.58	101.6	-4.08
Thigh	31.0	96.9	-3.15	99.2	-2.33

Results

Results of dose variation in exit dose assessments were shown in Fig. 2a. Mean dose measured by the EBT film is exactly the same as the mean value acquired by the ionization chamber. These results indicate that *in vivo* doses determined by the GAFCHROMIC® EBT film are accurate and reproducible (inter-dosimeter variety is within 2.8%). Based on the highly linear dose response ($R^2=0.9993$) of the GAFCHROMIC® EBT film illustrated in Fig. 2b, we can conclude that the use of EBT films for TBI dosimetry is very suitable. Table 1 surmised doses along central axis measured with EBT film pieces in the phantom. In comparisons with prescription doses, there is a -3.2% to 1.5% deviation found in the EBT film measurements which is an improvement over the TLD estimations which deviated from -4.2% to 5.7% from the prescription. In both patient cases, the measured doses of the GAFCHROMIC® EBT film samples were well within $\pm 5\%$ of the prescription dose. The agreement of measured doses between EBT films and TLDs were within 6.7% (-4.1% to 6.7%).

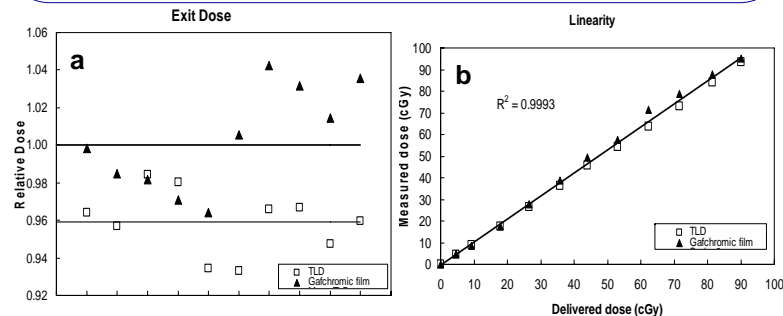


Fig. 2. (a) Comparisons of exit dose variation among values obtained from GAFCHROMIC® EBT films, TLDs and ionization chamber under TBI conditions. (b) Measured doses of GAFCHROMIC® EBT films and TLDs as a function of delivered doses determined by the ionization chamber.

Conclusions

The performance of the GAFCHROMIC® EBT film for TBI dosimetry has been evaluated using phantom measurements and *in vivo* studies for two patients. Specific characteristics of EBT films, such as accuracy, reproducibility, and linearity, under TBI conditions are reliable and compare favorably against TLDs. Our results have demonstrated that the GAFCHROMIC® EBT film is able to provide accurate results to evaluate the patient dose uniformity with less than $\pm 6.7\%$ variation from the prescription dose. Furthermore, the film's characteristics, such as self-processing, the almost water equivalent density, the water resistance, and insensitivity to room light, make this kind of radiochromic films easier to handle. The GAFCHROMIC® EBT film is a practical alternative to TLDs as an *in vivo* dosimeter in TBI radiotherapy.

References

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