Effect of magnetic field on the response of EBT-XD and EBT3 radiochromic films in MRIgRT

A. Darafsheh, Y. Hao, B. Maraghechi and R. Khan

Department of Radiation Oncology, Washington University School of Medicine, St. Louis, MO 63110

Optical Imaging and Dosimetry Lab

JULY 12–16 2020 VIRTUAL JOINT AAPM | COMP MEETING
EASTERN TIME [GMT-4]

INTRODUCTION

There is a constant need of using tissue equivalent 2D dosimeter for commissioning and routine clinical use in MRIgRT systems similar to the "conventional" radiotherapy machines. Radiochromic films, if correctly characterized for the challenges posed by the presence of the magnetic field, can address this need [1-4].

the purpose of this work is to study of the response of EBT3 and EBT-XD radiochromic films when irradiated in the presence of a clinical 0.35 T magnetic field at MRIgRT system.

METHOD

Two different models of radiochromic films, EBT3 and EBT-XD, were investigated.

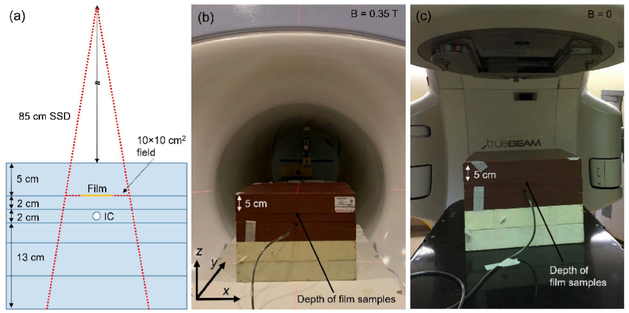
Pieces of films samples from two different batches for each model were irradiated at different dose levels ranging from 1 Gy to 20 Gy using 6 MV flattening filter free (FFF) x-rays generated by a clinical MR-guided radiotherapy system (B = 0.35 T).

Film samples from the same batch were irradiated at corresponding dose levels using 6 MV FFF beam from a conventional linac (B = 0) for comparison.

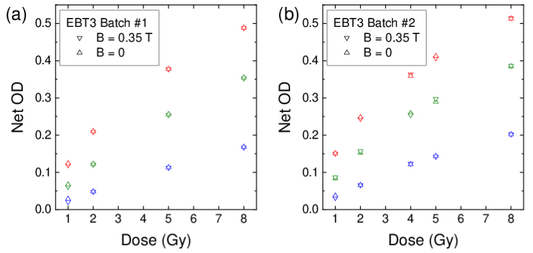
The net optical density was measured 48 h post-irradiation using a flatbed scanner.

The absorbance spectra were also measured over 500 nm -700 nm wavelength range using a fiber-coupled spectrometer with 2.5 nm resolution.

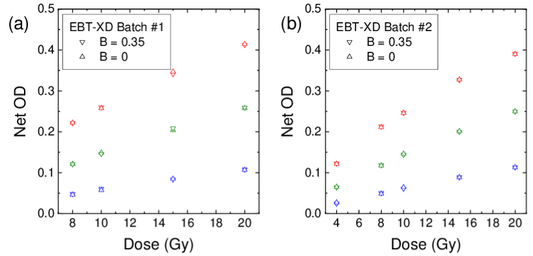
To study the effect of fractionated dose delivery to EBT3 (/EBT-XD) films, 8 (/16) Gy dose was delivered in four 2 (/4) Gy fractions with 24 h interval between fractions.



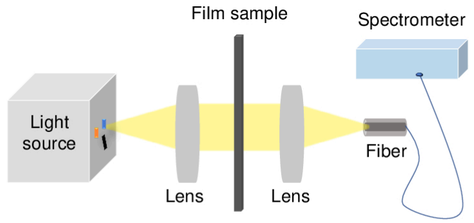
(a) Schematic of the irradiation geometry. Pictures of the experimental setup with (b) MR-guided MRIdian® linac (the table is retracted for presentation) and (c) TrueBeam™ linac [5].



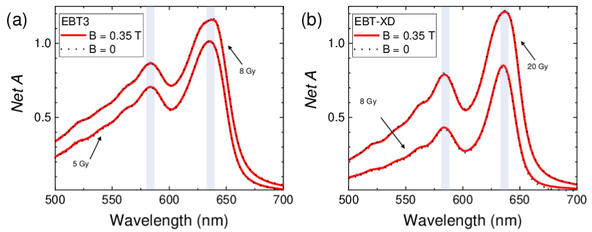
Net optical density for red, green, and blue color channels as a function of absorbed dose for EBT3 films: (a) batch #1 and (b) batch #2. The error bars are comparable to the symbol size [5].



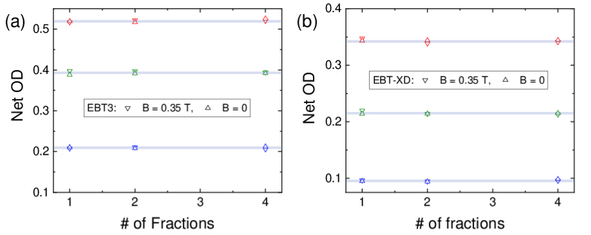
Net optical density for red, green, and blue color channels as a function of absorbed dose for EBT-XD films: (a) batch #1 and (b) batch #2. The error bars are comparable to the symbol size [5].



Schematic of the experimental setup used to measure the absorption spectra of the films using a fiber-coupled spectrometer (WP-VIS-R-S-100, Wasatch Photonics). Deuterium and tungsten halogen lamps (DH-2000, Ocean Optics) were used as the light source.



Net absorbance as a function of wavelength for (a) EBT3 batch #1 and (b) EBT-XD batch #1 films irradiated using both MRIgRT and Truebeam™ linacs. Vertical stripes correspond to the absorption bands [5].



Fractionated dose delivery for (a) EBT3 and (b) EBT-XD films with 24 h interval between fractions. The horizontal stripes are guides for eye. For EBT3 films, 8 Gy total dose was delivered in 1×8 Gy, 2×4 Gy, and 4×2 Gy fractions. For EBT-XD films, 16 Gy total dose was delivered in 1×16 Gy, 2×8 Gy, and 4×4 Gy fractions [5].

RESULTS

For both batches studied for each film model and all color channels, the 0.35 T magnetic field lead to the same response (within the uncertainties of the measurements) compared to the case where the magnetic field was absent.

We investigated the influence of duration of film exposure to the magnetic field before or after irradiating the films and did not observe any difference in the film response. Also, the response of the film did not change when the orientation of the reference edge was changed with respect to the B-field direction.

In both films models the primary and secondary absorption bands were observed at 635 nm and 583 nm, respectively. In both film models there is no significant difference in the absorbance of the films in terms of the spectral position and amplitude when irradiated with or without presence of the external magnetic field.

No significant difference (within the uncertainties of the measurements) was found based on the fractionation scheme.

CONCLUSIONS

Our thorough investigation did not show any significant difference in the net optical density and absorbance of the Gafchromic™ EBT3 and EBT-XD film models irradiated with and without the presence of a 0.35 T external magnetic field employed in an MR-Linac system. The study of both types of irradiated films with and without 0.35 T B-field using optical spectroscopy demonstrated identical spectra and absorption amplitudes. No significant dependency on the fractionation scheme was also noted.

REFERENCES

[1] Y. Roed *et al.*, *Radiotherapy and Oncology*, 123, S403 (2017).
[2] B. Delfs *et al.*, *PMB*, 63, 035028 (2018).
[3] D. Barten *et al.*, *PMB*, 63, 165014 (2018).
[4] I. Billas *et al.*, *PMB*, 64, 06NT03 (2019).
[5] A. Darafsheh *et al.*, *Medical Physics*, (2020) DOI: 10.1002/mp.14313.

CONTACT INFORMATION

Email: arash.darafsheh@wustl.edu