An adaptive method for recalibrating Gafchromic EBT3 film

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INTRODUCTION

EBT3 film is a widely used dosimetry tool. However, the film is recommended to be calibrated every half a year or even three months since the unexposed film slowly self-developed due to the dark current. This poses additional work for the physicists. To perform recalibration, a new method is proposed using an adaptive power function and no dose delivery is needed.

AIM

- Reduce the recalibration times of EBT films for film dosimetry.
- Save time and Save money.

METHOD

EBT3 film was calibrated four times at different dates with the last calibration date about eight months after the first.

- The dose-dependent optical density (OD) of the red channel was fitted to the delivered dose using a power function with a constant fitting parameter.
- In contrast to common methods of recalibrations, for which irradiations are required, the proposed method can calculate film-dose using only the fitting parameters of the first calibration and adapting the constant parameter using newly measured background OD.
- The film-dose calculated by the proposed adaptive method is compared with the given dose as percentage differences.
- Similar comparisons are also made using all new recalibrated fitting parameters and using only the first fitting parameters.

In details

- EBT3 film was calibrated on 2018/07/30, 2018/08/20, 2018/09/10 and 2019/03/25 using the “one red-channel after three-channel method” (Ref. 1). The dose-dependent optical density (OD) of the red channel, RD_n, for the n^{th} calibration, is fitted to the delivered dose using a power function:

METHOD CONTINUOUS...

$$D_{n\_fit} = a_n \times RD_n + b_n \times RD_n^{c_n} + d_n \ , \qquad (1)$$

where D_{n_fit} is the fitted dose for RD_n, and a_n, b_n, c_n, and d_n are fitting parameters for the n^{th} calibration. RD is the log of the dose-dependent inverse transmittance of the red channel. The fitting process included the data set of 0 cGy and RD_{n_bg}, the averaged RD_n of the n^{th} background images.

To skip the steps of irradiating films, a simply way to recalibrate film was developed by using a new introduced adaptive function:

$$D_{n\_film} = a_1 \times RD_n + b_1 \times RD_n^{c_1} + \delta_n \ , \qquad (2)$$

where D_{n_film} is the film dose of the n^{th} calibration and a_1, b_1, and c_1, are the fitting parameters of the 1st calibration. δ_n is the adaptive parameter of the n^{th} calibration and $\delta_1 = d_1$. Let us examine equation (1) of the first calibration, there exists an RD_1, named as $RD_{1\_fit\_bg}$, to make D_{1_fit} zero; that is, $a_1 \times RD_{1\_fit\_bg} + b_1 \times RD_{1\_fit\_bg}^{c_1} + d_1 = 0$. $RD_{1\_fit\_bg}$ can be solved using the “root of nonlinear function, *fzero*”, a Matlab function. Let ε be the difference between $RD_{1\_fit\_bg}$ and RD_{1_bg}, that is $RD_{1\_fit\_bg} = RD_{1\_bg} + \varepsilon$. For the n^{th} calibration, there is also an $RD_{n\_fit\_bg}$ to give zero film-dose; that is, $a_1 \times RD_{n\_fit\_bg} + b_1 \times RD_{n\_fit\_bg}^{c_1} + \delta_n = 0$ or $\delta_n = -[a_1 \times RD_{n\_fit\_bg} + b_1 \times RD_{n\_fit\_bg}^{c_1}]$. Supposing $RD_{n\_fit\_bg} \cong RD_{n\_bg} + \varepsilon$, for the n^{th} calibration, equation (2) can be rewritten as

$$D_{film} = a_1 \times RD_n + b_1 \times RD_n^{c_1} - [a_1 \times (RD_{n\_bg}+\varepsilon) + b_1 \times (RD_{n\_bg}+\varepsilon)^{c_1}] \qquad (3)$$

Therefore, the n^{th} film-dose can be calculated using a_1, b_1, c_1, RD_{n_bg} and ε. Without using a_n, b_n and c_n, means no dose delivery for the recalibration.

RESULTS

The results shown in Fig. 1 demonstrate that the difference between the film-dose with the delivered dose using the adaptive calibration method is within 3%. However, if still using the first set of fitting parameters calibrated on 2018/07/30, the difference is pretty high, greater than 50% for a given 50 cGy at the calibration date of 2019/03/25.

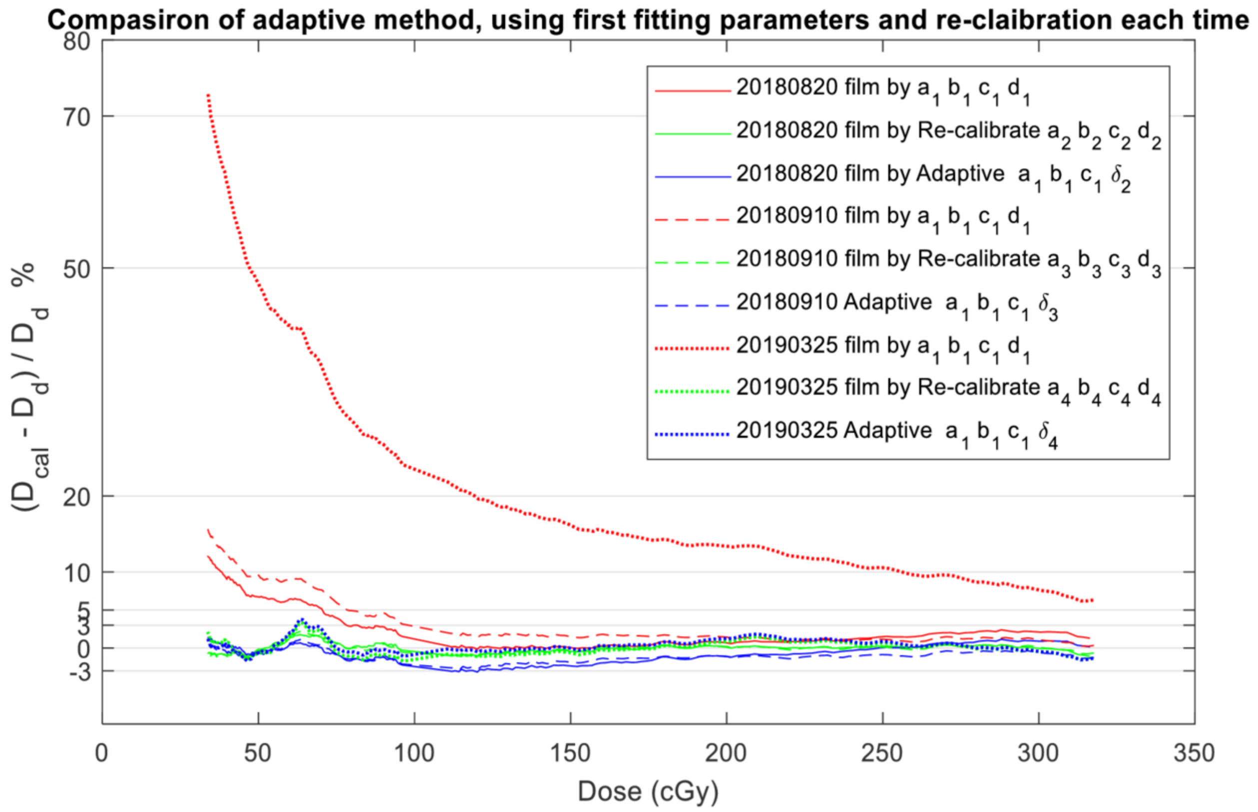

Fig. 1. The calculate film-dose (D_{cal}) compared with delivered dose (D_d) for the calibration date at 2018/08/20, 2018/09/10 and 2019/03/25 by using (1) the 1st fitting parameters calibrated at 2018/07/30 (red lines), (2) the fitting parameters recalibrated at the calibration date (green lines) and (3) the adaptive method by Eq. 3 (blue lines). ε = -0.002.

CONCLUSIONS

The film-dose can be calculated using the fitting parameters obtained from the first calibration together with the newly measured background OD to adapt the constant fitting parameter. With this method, recalibrating the film is not needed. To calculate the film-dose, the equation can be adapted specifically for each individual film at the time of usage. The presented method is convenient, time-saving and cost effective.

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REFERENCES

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