Non-Contact Scintillator Imaging Dosimetry for Total Body Irradiation in Radiotherapy

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Introduction

Current methods for monitoring patient dose in Total Body Irradiation (TBI) use OSLDs or TLDs. This requires careful handling to avoid mis-labelling the dosimeters which would report dose to incorrect anatomy. This process also requires time for the dosimeters to settle and be read which means that clinical teams won't have accurate dose monitoring for the first fractions of treatment. An example of a TBI setup is shown in Fig 1.

Non-Contact imaging dosimetry uses scintillators coupled with time gated cameras to report the dose administered to a patient. Prior work in TSET is shown in Fig 2. After calibration, this method should allow real-time dose readout. The work included initial testing with TBI conditions, including the inclusion of a plexiglass spoiler and bolus. Mock treatment of a body phantom, and comparisons to TLDs were also performed.

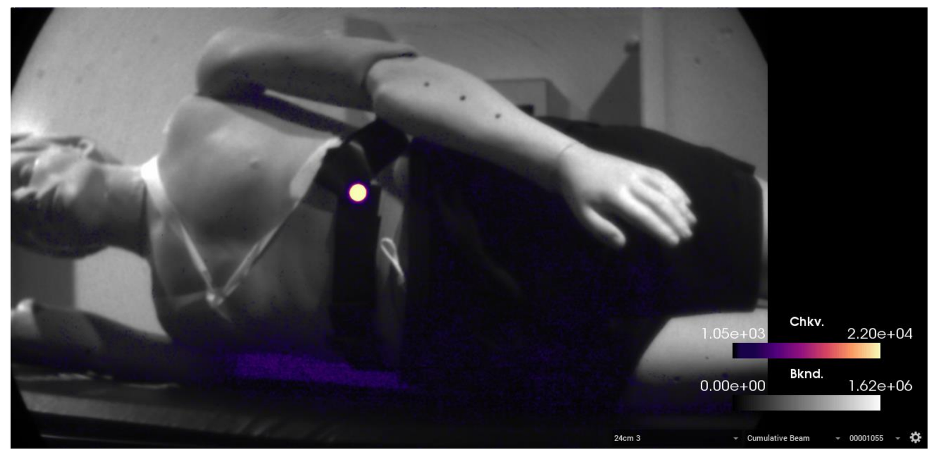

Figure 1: Phantom positioning during TBI treatment

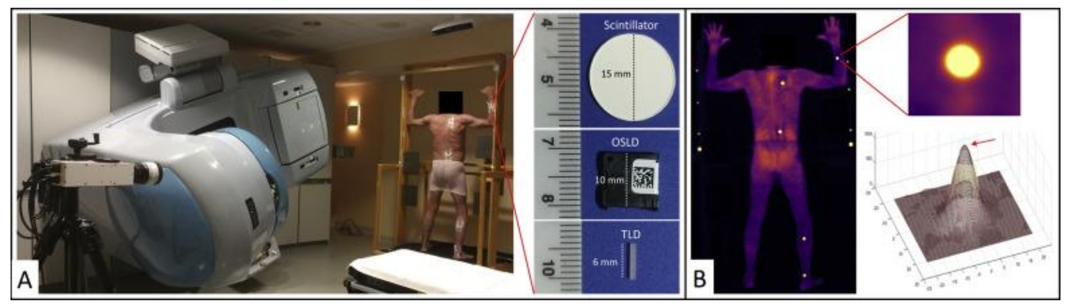

Figure 2: Prior work in total skin electron therapy (TSET) – Tendler et al, IJROBP 2019

Methods

Initial studies were completed on a flat tissue phantom that represented the color and buildup of soft human tissue. These studies also included bolus of varying thickness (Clearsight Bolus, Clearsight RT) and a 1cm thick plexiglass spoiler. Scintillation to dose linearity was assessed and compared with TLDs (TLD-100, Thermo Fisher Scientific).

Methods Cont.

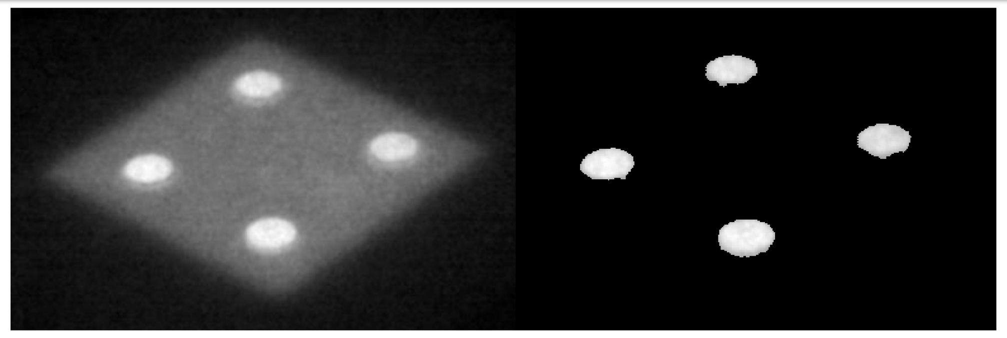

Figure 3: Demonstration of image processing to obtain scintillator signal

Figure 4: Patient Setup for treatment

Scintillator response was measured by a C-Dose (DoseOpticsLLC) time-gated camera. Scintillators (EJ-240, Eljen Tech) were affixed to a wavelength shifter (EJ-284, Eljen Tech) to better match the scintillator's emission spectrum with the camera's photocathode absorption spectrum. Average scintillator intensity was compared to TLD dose at each location. Fig 3 demonstrates how the scintillator signal was isolated for processing.

Once all the above was completed, a manikin was used for assessment in a human geometry as shown in figure 4.

For all studies, LINAC (TrueBeam, Varian) was used at an SSD of 375cm, typical for TBI treatments. 3 scintillators (Eljen Technologies) were placed on its forehead, chest, and umbilicus to report dose to the eyes, lungs, and intestines, respectively.

Results

Figure 5: C-Dose images of scintillators on a flat plane without the plexiglass spoiler, with the spoiler, and with the spoiler and bolus

Barrier Type	SBR
No Barrier	25.6
Plexiglass Spoiler	22.0
3mm Bolus	9.2
3mm Bolus and Plexiglass	7.7
5mm Bolus	6.2
5mm Bolus and Plexiglass	5.0
10mm Bolus	5.2
10mm Bolus and Plexiglass	4.4

Table 1: Effects of plexiglass spoiler and bolus on scintillator SBR

Figure 5 and Table 1 demonstrate the effect of spoilers and bolus on the scintillation signal, respectively. Figure 6 shows the C-Dose image using TBI geometry. In Figure 7 the scintillation signal is plotted as a function of the TLD-measured dose. This combined plot for all tests across all measured body sites showed good linearity ($R^2 = 1$). Mean error for scintillator and TLD on human geometry measurements was 0.87 ± 0.39% and 1.57 ± 0.51% respectively.

Results

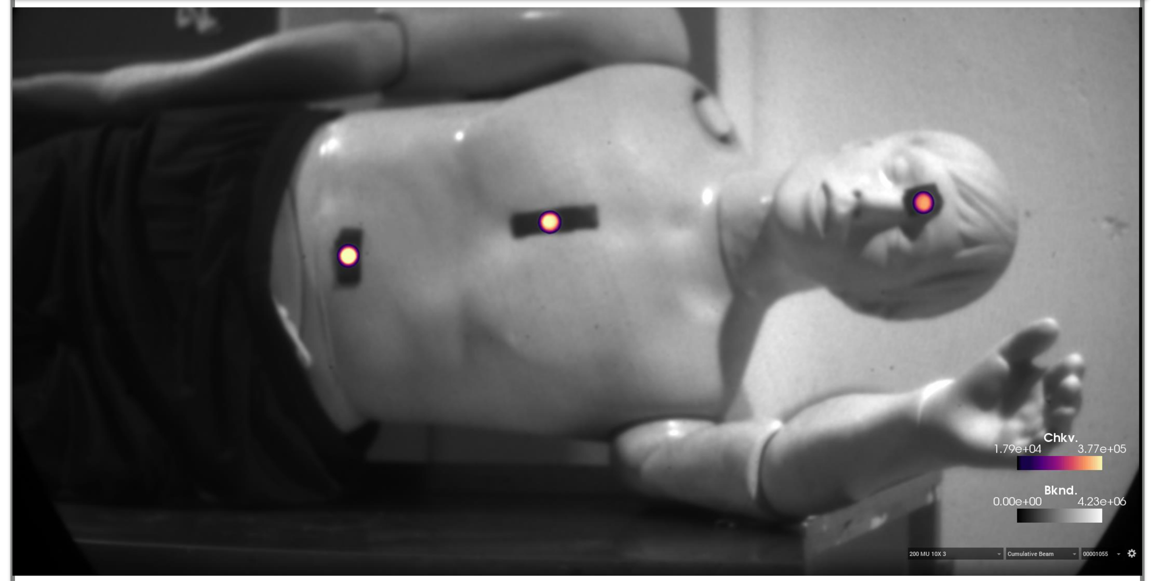

Figure 6: Resulting image of scintillators on patient

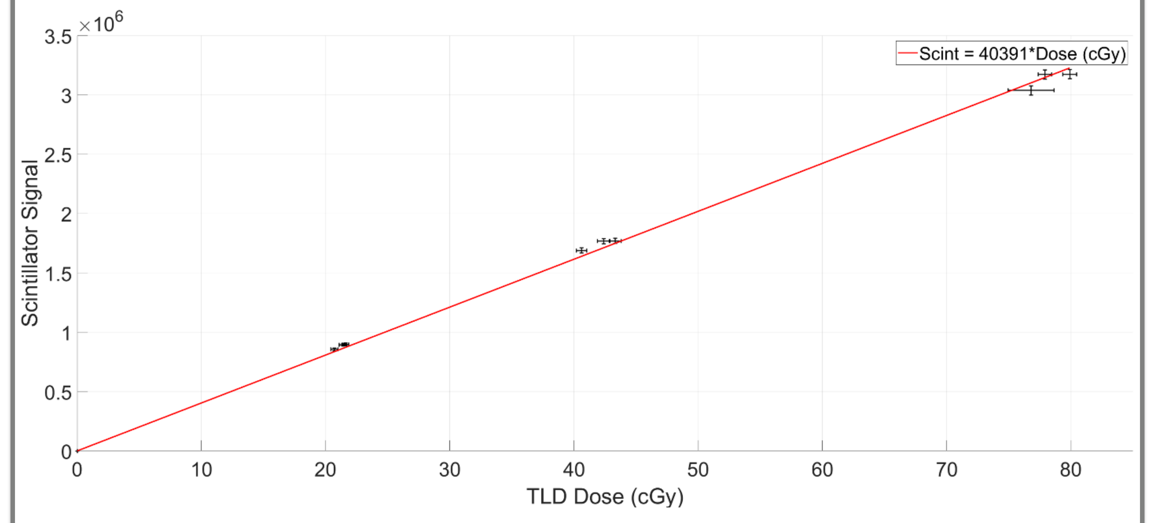

Figure 7: Combined Dose-Scintillation curves for abdomen, chest, and eyes

Conclusions

The effect of materials that increase surface dose can be seen in real time with this method, and under 2cm of material the scintillators were still clearly visible and useful. Scintillators at each location on the phantom showed good linearity in their response to the dose administered. This shows promise for use in real time clinical measurements of delivered dose.

Future work based on these results would be to determine the best camera/scintillator/wavelength shifter combination to increase SNR for image processing and to automate the process for clinicians.

Acknowledgments

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