Clinical Implementation of Optically-Stimulated Luminescent Dosimeters (OSLDs) toward Dose Verification of Rotational Total Skin Electron Treatment (TSET)

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Purpose: Mycosis fungodies (MF) is the most common type of cutaneous T-cell lymphoma and manifests as an excessive accumulation of malignant lymphocytes in the skin. A palliative treatment strategy for MF is total skin electron therapy (TSET), which typically consists of six fractions using 6 MeV electrons to 2 Gray (Gy) for a total skin dose of 12 Gy.

Professional organizations (ACPSEM, EORTC, AAPM) recommend TSET field uniformity within ±10% of the prescription dose at the treatment plane. However, achieving a similarly uniform dose across the entire skin is challenging due to variations in patient size, setup, and anatomy. Therefore, dosimetric measurements at multiple body sites are required to ensure proper dose distribution.

Davis et al.[1] outlines the clinical use of beryllium oxide (BeO) optically stimulated luminescent dosimeters (OSLDs) for in-vivo dosimetric measurements. This work presents an implementation of OSLD use for dose verification of TSET, which in turn provides some practical advantages compared to other dosimeter types.

Methods: The UVA TSET program consists of a Varian TrueBeam linear accelerator (Varian Medical Systems, USA) and rotational platform ((RPD, Inc. Model 495-605).Clinical setup is outlined in Figure 1.

Figure 1. TSET rotational platform setup and treatment visualization. (a) The rotational platform consists of a rotating stand, free-moving handle bar with optional head and hand shields, and electron spoiler. (b) A single fraction consists of two beams angled at ±19° from horizontal. For each beam, the platform and patient rotate 9 times for a duration of 3 minutes. (c) Example mock patient setup, with sample OSLD and/or radiographic film placement.

RadPro (RadPro International GmbH, Germany) OSLDs, myOSLchip reader, eraser, and OSLDosimetry software (v1.20.5) were utilized for OSLD calibration and dose readout. Per vendor recommendations, the reader, individual OSLDs, and system were calibrated using a single-point calibration at 50 cGy.

GafChromic EBT4 film (Lot #02032503; Ashland, USA) served as a comparative standard to OSLDs for calibration, phantom, and in-vivo dosimetry (Figure 2). EBT4 film was scanned with an Epson Expression 10000XL (Epson, Japan) and analyzed using DoseLab (Varian Medical Systems, USA).

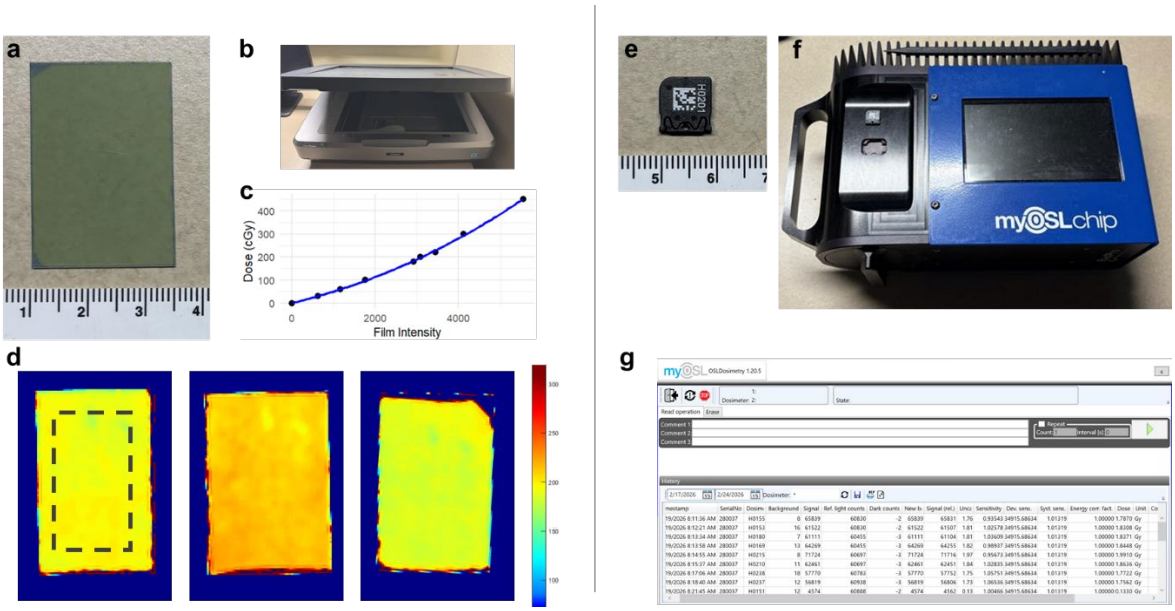

Figure 2. (a) Example 1” x 1.5” cut piece of EBT4 film used for in-vivo dosimetry. (b) Epson scanner utilized for scanning film. (c) Film 3rd-order polynomial calibration curve. (d) DoseLab analysis of GafChromic film with an example dotted box representing the sampled region for dose readout. (e) Example OSLD form factor. Note that film in (a) and OSLD are scaled to comparative size. (f) RadPro OSLD reader (g) Powerful OSLDosimetry software used for calibration and dosimetric readout from the OSLD reader.

A calibration check was performed at clinically relevant levels of 180, 200, 220 monitor units (MU, 1 MU = 1 cGy at maximum water depth dose) of 6 MeV electrons with 1.3 cm of water-equivalent buildup.

In order to evaluate the variance in TSET doses between OSLDs and film across a variable human-like surface, a soft-tissue-equivalent Alderson Radiation Therapy (ART) phantom (Radiology Support Devices, USA) was placed on the rotating platform. A 2.54 x 3.81 cm film strip and two OSLDs were placed at various locations around the phantom, with film and OSLD placements < 2.5 cm apart. The ART phantom was then irradiated with a full fraction (200 cGy) of TSET.

Finally, in-vivo dosimetry was performed with a patient. Clusters of two OSLDs and a film strip were attached to the patient’s skin at various locations to evaluate dose homogeneity of a single fraction.

Results: The secondary calibration comparison between OSLDs and GafChromic film for the dosimetric range of 180–220 cGy are reported in Figure 3. While the variance of the film calibration curve was lower (r^2=0.999) compared to the OSLD (r^2=0.927), there was closer agreement between the OSLD measurements and standard conditions (2.9, -2.3, and 2.3% deviation for 180, 200, and 220 MU, respectively) compared to film (-4.0, -3.0, and -3.3% deviation for 180, 200, and 220 MU, respectively).

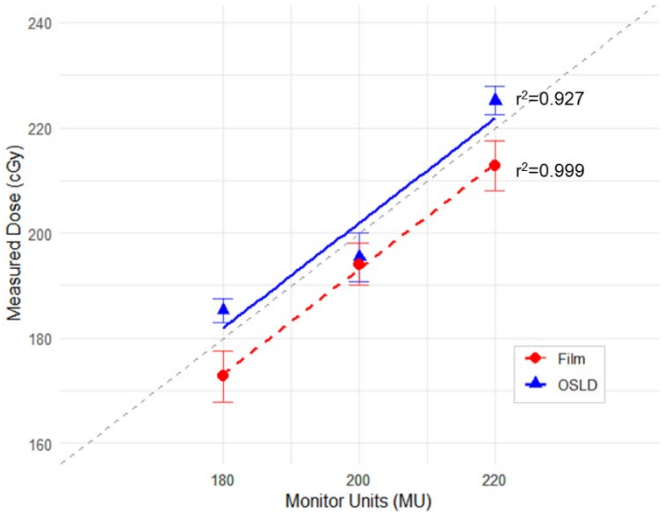

Figure 3: Comparison of calibration conditions between OSLD and GafChromic film at 180, 200, and 220 MU. The gray dotted line represents a perfect 1:1 ratio. Error bars represent ± 1 standard deviation.

ART phantom dosimetric readings for OSLDs and film at one full fraction of 200 cGy TSET are reported in Figures 4 and 5. The greatest deviation between OSLD and film reading occurred for the inner thigh region, which was mostly likely due to limited setup space for identical sampling. Other locations with higher deviation (>5%) were the anterior abdomen (10.7%), left neck (7.8%), and left shoulder (6.2%).

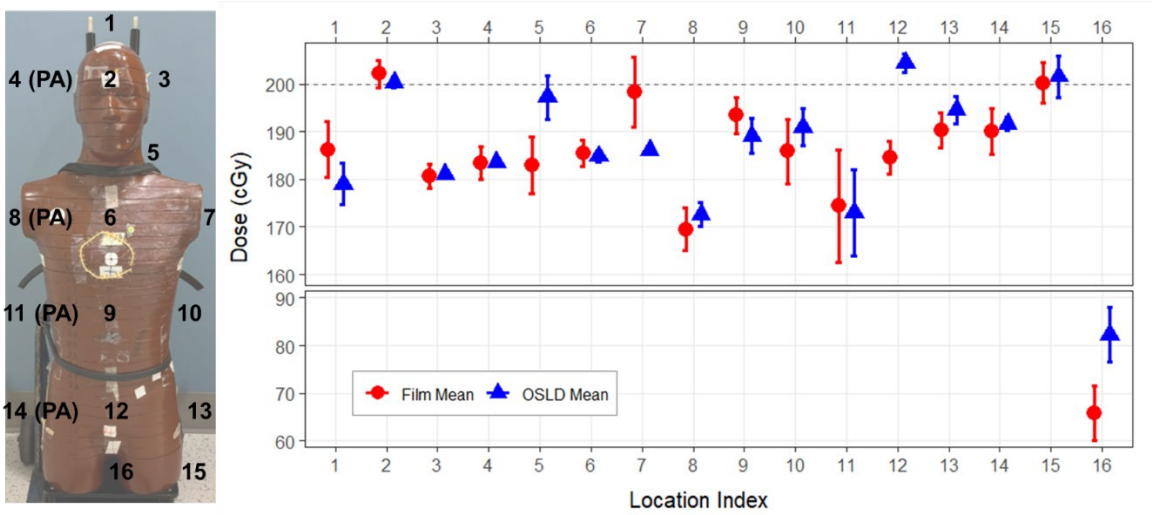

Figure 4: OSLD and film dosimetric measurements for 16 locations around the ART phantom for a single 200 cGy TSET fraction.

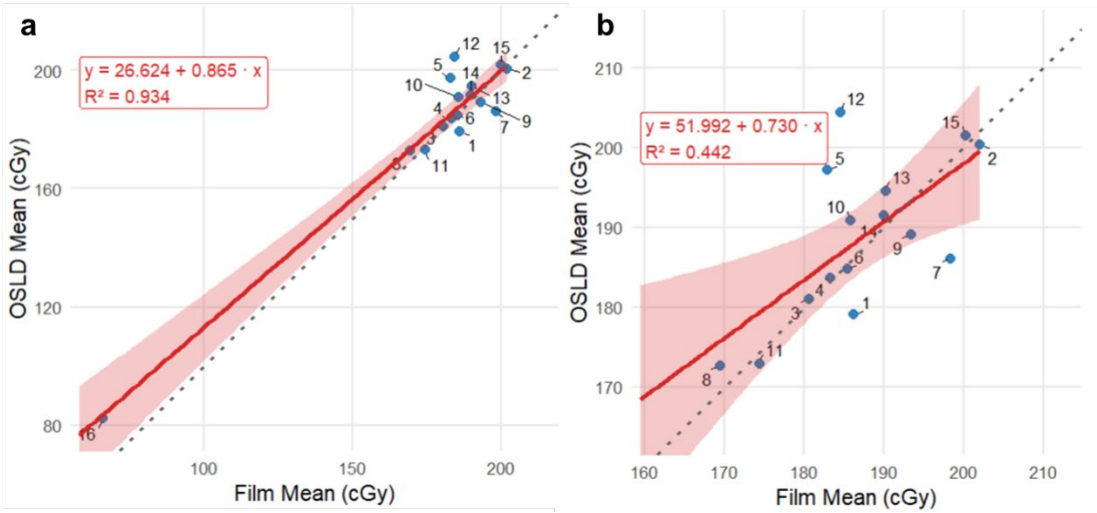

Figure 5: Association between mean film dose (x-axis) and OSLD dose (y-axis) for phantom locations in Figure 4. Red line/shaded region represent best fit and 95% confidence interval, respectively. (a) Visualization and statistical analysis for all 16 locations and (b) omitting inner thigh dose.

In-vivo single-fraction dosimetric measurements for OSLDs and film are reported in Figures 6 and 7. Highest variance between OSLD and film occurred within the head shield and at low dose (<16 cGy). Other high deviations (>5%) between OSLD and film occurred at the lateral foot (6.6%) and inferior-facing upper extremity (5.5%).

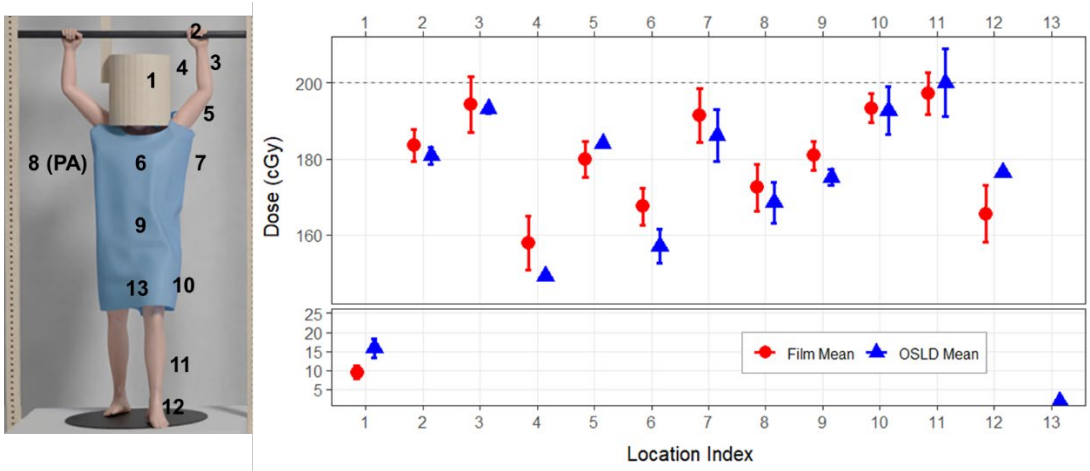

Figure 6: OSLD and film in-vivo dosimetric measurements for 12 locations for a single 200 cGy TSET fraction.

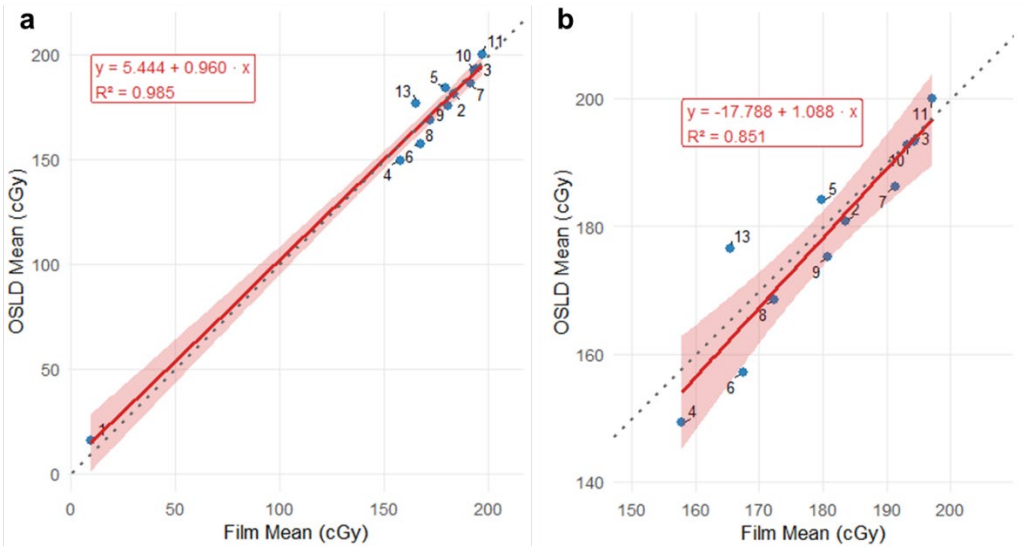

Figure 7: (a) Association between mean film dose (x-axis) and OSLD dose (y-axis) for in-vivo locations in Figure 6, with (b) omission of low-dose readings.

Conclusions: OSLDs provided a comparable dose reading to film measurements within our results. In addition to suitable dosimetric accuracy, practical considerations such as patient comfort and overall ease of use make OSLDs an excellent choice for in-vivo TSET dosimetry.

Relevance to CIRMS: This body of work presents a method to measure ionizing radiation via OSLDs and validate their use for in-vivo dosimetry of clinical radiation therapy.

References:

1. H. Davis, et al. “Clinical validation of myOSLchip: A beryllium oxide optically stimulated luminescent dosimeter (OSLD) system in radiotherapy dosimetry”, *J Appl Clin Med Phys*. 26, e70094 (2025).