In Vivo Dosimetry for Superficial HDR Brachytherapy with OSLDs: A Comparison Study with MOSFETs

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Introduction

- The occurrence of skin cancer worldwide has been on the rise for the past 30 years, making it the most common type of malignancy in many countries, including Canada, America, and Australia [1]
- Traditionally, non-melanoma skin cancers are removed surgically however obtaining cancer-free margins endangers cosmetic and functional outcomes [2]
- High dose rate (HDR) brachytherapy allows hypofractionated treatments and excellent tumour coverage [3]
  - Metal-oxide-semiconductor field-effect transistors (MOSFETs) are common in vivo dosimeter used to measure target and organ-at-risk (OAR) doses; however, MOSFETs are very cumbersome [4]
- Optically stimulated luminescent dosimeters (OSLDs) are a newer type of in vivo dosimeter being introduced into HDR brachytherapy for their ease of use and cost effectiveness [3]
- In this study, we calibrated and commissioned Landauer nanoDot™ OSLDs to be used in place of the mobile MOSFET single-channel dose verification system for in vivo dosimetry in contact-based treatments for superficial HDR brachytherapy

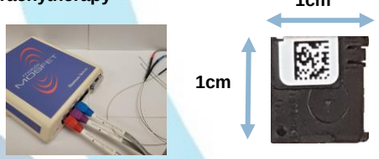

Figure 1: (Left) Mobile MOSFET (Right) NanoDot™ OSLD

References
1) Apalla Z, Lallas A, Sotiriou E, et al. Derm Pr Concept 2017;7:1-6
2) Taylor JM, Dasgeb B, Liem S, et al. Adv Radiat Oncol 2020;6:100616
3) Sharma R, Jursinic PA. Med Phys 2013;40:071730
4) Tanderup K, Beddar S, Andersen CE, et al. Med Phys 2013; 40;070902

Methods

- An 192-Ir seed was the radioactive source throughout this study delivered by the Nucletron Flexitron afterloader
- Solid water phantoms were used to irradiate OSLDs to known doses to build three calibration curves as follows:

Calibration type	Dose range (cGy)	Dose used to build curve (cGy)
Low dose (linear)	0-10	0, 3, 6, 9, 12
High dose (linear)	10-300	50, 150, 300
High dose (non-linear)	>300	50, 100, 300, 500, 800, 1000, 1300

Table 1: Three calibration for the wide range of possible OSLD exposures

- The following OSLD commissioning tests were conducted:
  1. Dose linearity
  2. Dose rate dependence
  3. Angular dependence
  4. Readout depletion
  5. Optical annealing

Figure 2: Solid water phantoms used for calibrating and commissioning OSLDs. (Left) Calibration and tests 1, 4 (Middle) Test 2 (Right) Test 3

- We decided to compare the performance of OSLDs and MOSFETs with an end-to-end phantom test representative of treating a facial lesion with a 3cm horizontal Valencia applicator
  - The simulated OAR was the lens of the eye which was 2cm from the target region

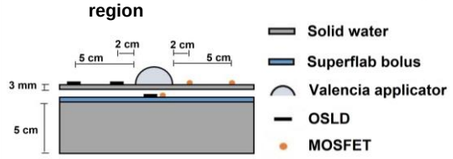

Figure 3: End-to-end test phantom design

Results and Discussion

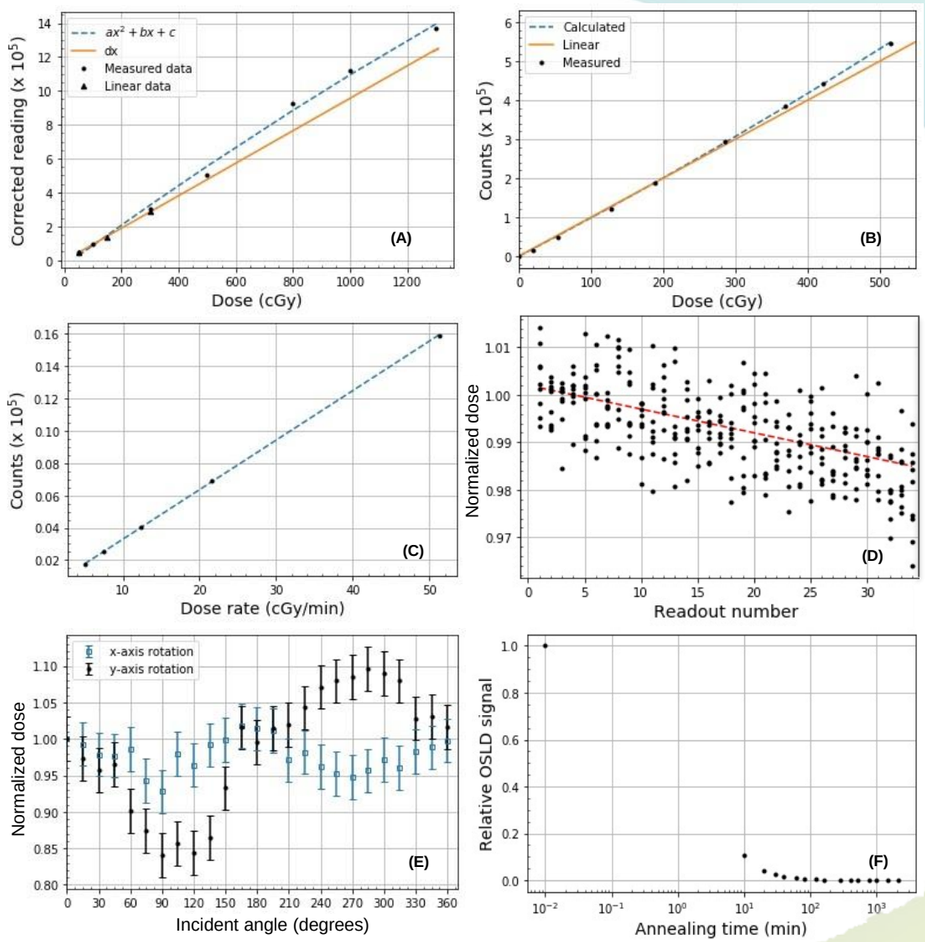

Figure 4: (A) Calibration curves (B) Dose linearity (C) Dose rate dependence (D) Readout depletion: Incident angle of 0° corresponds to the QR code face of the OSLD (as shown in Figure 1), 90° to the thin edge of the OSLD case, 180° to the OSLD lot number face, and 270° to the thick edge of the OSLD case (E) Angular dependence: Error bars give one standard deviation (F) Optical annealing

- We were able to show that OSLDs exhibit a supralinear response to doses above 300 cGy, which supports Landauer's recommendation to use a non-linear curve for reading out OSLDs expected to have an absorbed dose of 300 cGy or higher
- OSLDs were found to be independent of dose rate and exhibit a 0.05% depletion in signal per readout
  - These results show OSLDs can be readout up to ten times without having a statistically significant effect on the dosimetric readout
- Rotation about the x- and y-axis of the OSLD was found to be significant with deviations as high as 7% in the x-axis and 16% in the y-axis
  - OSLDs should be positioned with its face orthogonal to the expected incident dose gradient to avoid angulation effects during readout
- Using an x-ray light box, we were able to show OSLDs can be optically annealed to 10% of its original signal within the first 10 minutes of light exposure
  - Optical exposure for ~24 hours leaves each OSLD with 0.01% of its original signal
  - OSLDs can successfully be optically annealed and reused
- The dosimetric results for the end-to-end test were as follows with a dose of 600 cGy delivered to the target:

Measurement site	Measured OSLD dose (cGy)	Measured MOSFET dose (cGy)	OSLD/MOSFET % difference
Target	599.5	602	0.42
OAR	11.15	11.4	2.17

Table 2: Dosimetric comparison between OSLDs and MOSFETs

- Both OSLDs and MOSFETs were found to agree within±5% of the delivered dose to the target, which was defined as the acceptable range
  - OSLDs agreed to within 0.09% whereas MOSFETs agreed to within 0.33%

Conclusion

OSLDs can successfully be used in place of MOSFETs for in vivo dosimetry in contact-based treatments for superficial HDR brachytherapy

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