INTERFACE AND SMALL RADIATION FIELD DOSIMETRY USING A MOSFET-BASED DETECTOR

W.L. Jong[1], N.M. Ung[1], J.H.D., Wong[2],

[1] Clinical Oncology Unit, Faculty of Medicine, University of Malaya, Kuala Lumpur, Malaysia
[2] Department of Biomedical Imaging, Faculty of Medicine, University of Malaya, Kuala Lumpur, Malaysia

Abstract— **Accurate dosimetry is a critical step in radiotherapy. Generally, essential dosimetric parameters are measured in a relatively flat and homogeneous water phantom, where charged-particle equilibrium (CPE) exists. However, dosimetry in certain conditions such as skin, small radiation field and interface region of two different media, CPE does not exist and therefore, poses challenges to achieve dosimetric accuracy. For accurate dose measurements in non-CPE conditions, a detector should have a small sensitive volume and water equivalent packaging to avoid dose perturbation effect. In this study, the feasibility of a MOSFET-based detector, the MO*Skin* detector (Fig. 1) for skin, small radiation fields and interface dose measurements were investigated. The advantages of the MO*Skin* detector are its water equivalent depth of 0.07 mm, small sensitive volume and water equivalent packaging.**

The MO*Skin* detector was first characterised for *in vivo* dosimetry under megavoltage photon and electron beams. Then, the MO*Skin* detector was used to measure patients' skin dose in tangential breast radiotherapy and compared against dose threshold for different skin reactions. The clinical application (Fig. 2) showed that the MO*Skin* detector is suitable for *in vivo* dosimetry and it is necessary to accurately determine the skin dose for better clinical management of skin complications.

The suitability of the MO*Skin* detector in "Edge-on" orientation (Fig. 3) for small radiation field was investigated. Results showed that the MO*Skin* detector (Fig. 4) is suitable for dose assessment in small radiation fields as compared to other commercial detectors. The feasibility of the MO*Ski*n detector for dosimetric verification in stereotactic radiotherapy was also tested. The result shows that it is a suitable verification tool for stereotactic radiotherapy.

Challenges in treating a lung tumour are related to respiratory-induced tumour motion and accuracy of treatment planning dose calculations in non-CPE conditions. The dosimetric characteristics near the interface of lung and Perspex media during static, respiratory-gated and non-gated (moving) radiotherapy were investigated using Gafchromic EBT2 film and the MO*Skin* detector in a moving phantom. In non-gated radiotherapy, dose smearing effect was observed and this effect was reduced in respiratory-gated radiotherapy (Fig. 5). However, there were still some dose discrepancies due to residual motion. The accuracy of different dose calculation algorithms near interface region was evaluated. It was found that over-estimation of the dose coverage will lead to the choice of smaller field size and thus, under-dosage to the tumour. Therefore, better dose calculation algorithms are essential.

In conclusion, the MO*Skin* detector has been characterised and used for dosimetric assessment in the non-CPE regions. The results suggest that the MO*Skin* detector possesses suitable physical characteristics for dosimetric assessment of interface and small radiation field.

Keywords— ***in vivo* dosimetry, quality assurance, characterisation, stereotactic radiotherapy, skin dosimetry, electron beam dosimetry.**

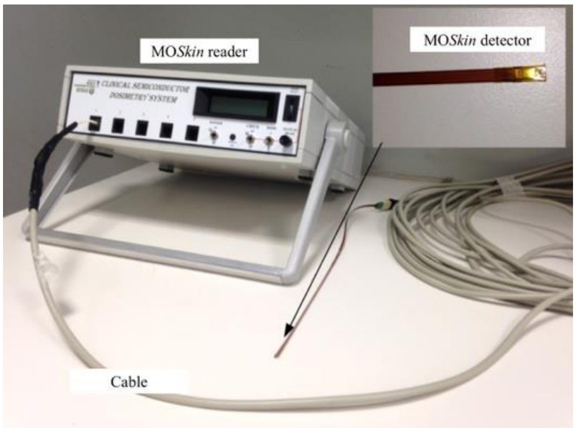

Fig. 1 The MO*Skin* detector system

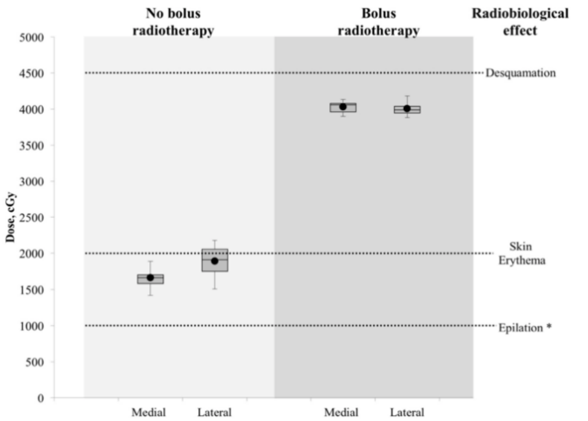

Fig. 2 Total skin dose for 13 patients who underwent "no bolus radiotherapy" and "bolus radiotherapy". The black dots show the average total skin dose. The dotted lines show the dose threshold for different skin reactions. *This radiobiological effect does not occur on the breast but it may appear on other skin sites.

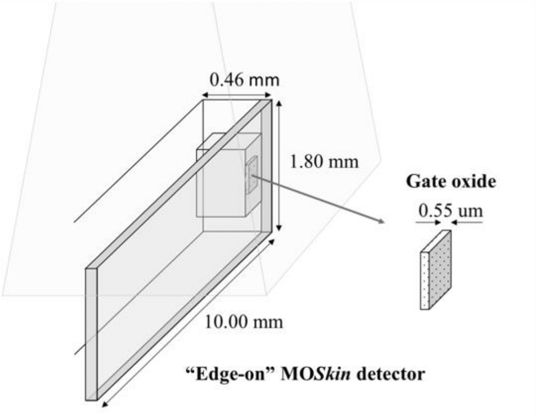

Fig. 3 The MO*Skin* detector in "Edge-on" orientation.

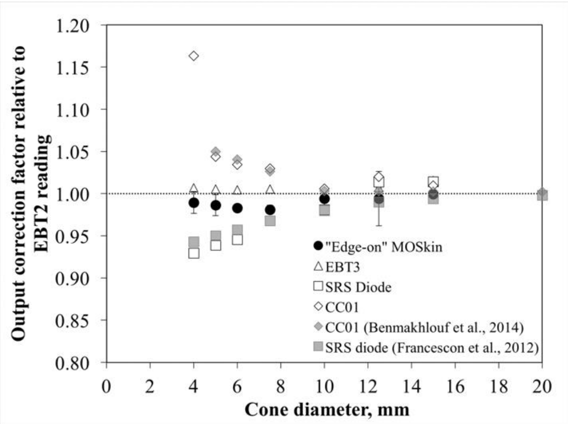

Fig. 4 Measured output correction factors for the "Edge-on" MO*Skin* detector and SRS diodes. All set of factors are derived from the EBT2 film measurement. The error bar shows the quadrature-combined uncertainties (1 SD) of the "Edge-on" MO*Skin* detector and the EBT2 film readings.

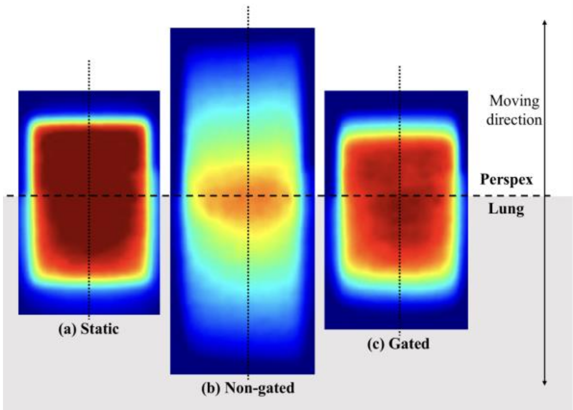

Fig. 5 Measured dose distribution using EBT2 film near the lung and Perspex interface during static radiotherapy (no motion), non-gated radiotherapy (motion amplitude of 40 mm) and gated radiotherapy with 25% gating window (motion amplitude of 40 mm).

References

1. Jong, W. L., Wong, J. H. D., Ung, N. M., Ng, K. H., Ho, G. F., Cutajar, D., & Rosenfeld, A. (2014). Characterisation of MO*Skin*TM detector for *in vivo* skin dose measurement during megavoltage radiotherapy. *J Appl Clin Med Phys, 15*(5), 120-132.
2. Jong, W. L., Ung, N. M., Wong, J. H. D., Ng, K. H., Wan Ishak, W. Z., Abdul Malik, R., Phua, V. C. E., Cutajar, D., Metcalfe, P., Rosenfeld, A., & Ho, G. F. (2016). *In vivo* skin dose measurement using MO*Skin* detectors in tangential breast radiotherapy. *Phys Med, 32(11),* 1466-1474.
3. Jong, W. L., Ung, N. M., Vannyat, A., Jamalludin, Z., Rosenfeld, A., & Wong, J. H. D. (2017). "Edge-on" MO*Skin* detector for stereotactic beam measurement and verification. *Phys Med, 33*, 127-135.
4. Jong, W. L., Ung, N. M., Vannyat, A., Rosenfeld, A., & Wong, J. H. D. (2017) Dosimetric evaluation near lung and soft tissue interface region during respiratory-gated and non-gated radiotherapy: a moving phantom study. *Phys Med. 42*, 39-46.
5. Jong, W. L., Ung, N. M., Tiong, A. H. L., A., Rosenfeld, A., & Wong, J. H. D. (2018). Characterisation of the MO*Skin* detector for dose measurement under megavoltage electron beam. *Radiat Phys Chem, 144*,76-84.

Contacts of the corresponding author:

Author: W.L. Jong
Institute: University of Malaya
City: Kuala Lumpur
Country: Malaysia
Email: wljong88@gmail.com