In vivo dosimetry: Optical fibre characterisation for use in adaptive HDR pelvic brachytherapy

Orla A Houlihan*[1,2], Owen McLaughlin*[2,3], Emma Marlow[2], Sergio Esteve[3], Geraldine Workman[3], Monica Byrne[3], Agnieszka Gierej[4], Tigran Baghdasaryan[4], Jürgen Van Erps[4], Francis Berghmans[4], Conor McGarry[3], Mark Grattan[3], Sinead O'Keeffe[5], Kevin M. Prise[2], Alan Hounsell[2,3], Suneil Jain[1,2]

*Authors contributed equally.

1. *Department of Clinical Oncology, Northern Ireland Cancer Centre, Belfast City Hospital, Belfast, Northern Ireland*
2. *Patrick G. Johnston Centre for Cancer Research, Queen's University Belfast, Belfast, Northern Ireland*
3. *Department of Radiotherapy Medical Physics, Northern Ireland Cancer Centre, Belfast City Hospital, Belfast, Northern Ireland*
4. *Brussels Photonics (B-PHOT), Department of Applied Physics and Photonics, Vrije Universiteit Brussel and Flanders Make, Pleinlaan 2, B-1050 Brussels, Belgium*
5. *Optical Fibre Sensors Research Centre, Department of Electronic & Computer Engineering, University of Limerick, Limerick, Ireland*

Purpose

To characterise and calibrate optical fibre sensors as a first step in the integration of optical fibre sensors, developed as part of the EU funded H2020 project "ORIGIN", within HDR pelvic brachytherapy for use in adaptive brachytherapy.

Materials and Methods

Three optical fibre prototypes connected to scintillation detectors were used to undertake measurements on an Elekta Flexitron HDR system. Initial measurements were performed by placing each fibre in turn within a HDR prostate Perspex needle phantom capable of holding 20 HDR needles in parallel, placed between two solid water blocks. For ease of positioning the fibre was placed within a plastic HDR needle catheter inserted in a central channel within the phantom and the ^{192}Ir source was afterloaded to the most distal dwell position within a separate HDR catheters. The source catheter was positioned such that the source was aligned with the scintillating tip of the fibre, at 1 cm, 3 cm and 5 cm source-sensor distances in turn, for a dwell time of 10 seconds (Fig. 1). Measurements were performed four times without altering the setup to assess repeatability.

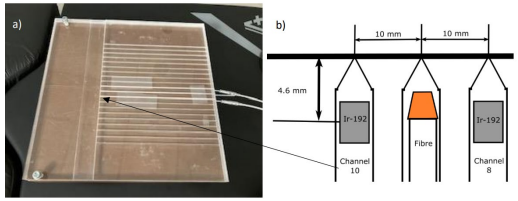

Fig.1. a) Setup for initial brachytherapy measurements using Perspex prostate needle phantom. b) Schematic of the setup in the image with needles at the end of each channel in the phantom.

Materials and Methods

Three additional output measurements for varying source-sensor distances were acquired using one fibre placed within a brachytherapy catheter containing an internal polytetrafluoroethylene (PTFE) tube to reduce positional uncertainty of the fibre tip. The scintillating fibre tip was exposed to the ^{192}Ir source at 1 cm incremental distances from 1 cm to 10 cm. Photon count rates of each of the three measurements corresponding to each distance were averaged. These count rates were then compared to absolute dose calculations from the Oncentra Brachytherapy (v4.6.1) treatment planning system.

Results

Variability in terms of repeatability measurements ranged from 0.22%-1.58% at 1 cm distance, 0.18% - 0.74% at 3 cm and 0.35%-0.85% at 5 cm from the ^{192}Ir source. The background subtracted photon count rate and expected TPS dose, normalized to 10Gy at 1cm, differed at incremental distances from the source (Fig. 2). All calculated coefficients of determination were > 0.99.

Conclusions

The optical fibre sensors demonstrated **< 1% variability in repeatability** measurements **at distances ≥ 3 cm from the ^{192}Ir source**. The difference in output at incremental distances from the ^{192}Ir source compared with the treatment planning system indicates the need for exploration of the fibre sensors' energy dependence and the calculation of a correction factor.

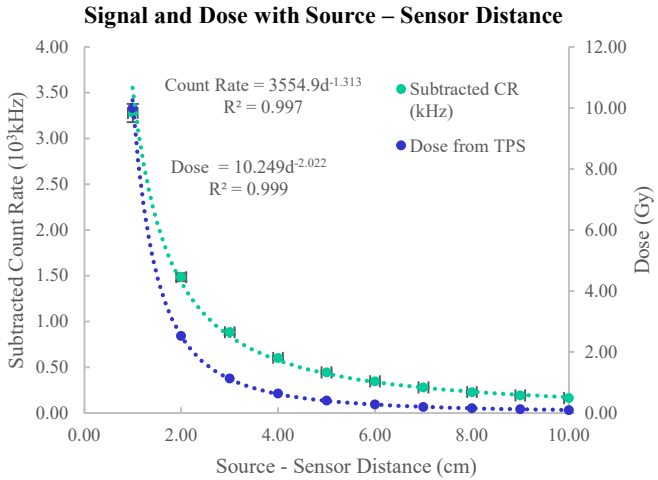

Fig. 2. Source-sensor distance versus photon count rate (kHz) following exposure to the ^{192}Ir source for a dwell time of 10 seconds.

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