Organic scintillator dosimetry system for end-to-end independent verification of preclinical radiotherapy plans delivered with SARRP

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Used with appropriate mouse/cancer models, Image-Guided Small Animal Radiotherapy Platforms (IGSARP) are essential to the development of new clinical cancer treatment strategies. Independent systems for end-to-end dose verification are crucial to evaluate the accuracy levels of current preclinical radiotherapy practices and consistency of the research outcomes.

Preclinical radiotherapy with SARRP IGSARP (Xstrahl) is delivered with beams in the medium energy x-ray range and small fields. Dosimeters currently used for dose verification (e.g., TLD, Gafchromic film and alanine) required intense postprocessing.

The HYPERSCINT Scintillation Research Platform 200 was characterized in a SARRP device. The position of the 1 mm detector within the optical fibre was verified with a microCT scan. Scintillation and fluorescence fibre calibration was performed using SARRP's imaging capabilities.

Subsequently, dose calibration for SARRP treatment parameters (220 kV, 13 mA, 0.84 mm Cu HVL) was performed against a secondary standard, traceable to the UK Air Kerma primary standard. Linearity with dose, response to variation of the dose rate and to beam quality in the medium energy x-ray range were investigated. For the end-to-end test, treatment plans with variety of complexity (direct, oblique, arcs) and field sizes (3, 5 and 10 mm) were delivered to homogeneous and inhomogeneous phantoms (Figure 1).

Dose calculated by Muriplan (SARRP's treatment planning system) were compared to dose measured by the scintillation system. Hyperscint response is linear with dose (R=1, 0-15 Gy) and has no significant dependence with dose rate variation (<0.2%, for 0-3 Gy/min). It shows a linear response with variation of the beam quality in the medium energy x-ray range available in SARRP (0.5 to 0.84 mm Cu).

For the end-to-end test, it was possible to localize and target the scintillator as a planning treatment volume (PTV). Calculated versus measured dose difference was within ±3.2% for all delivered types of plans (Figure 2). Hyperscint-mouse phantom combination proved satisfactory for the implementation of end-to-end tests in preclinical radiotherapy with small animal research platforms.

The main advantage of the proposed methodology is the immediacy of the results for the comparison with the treatment planning calculated dose.

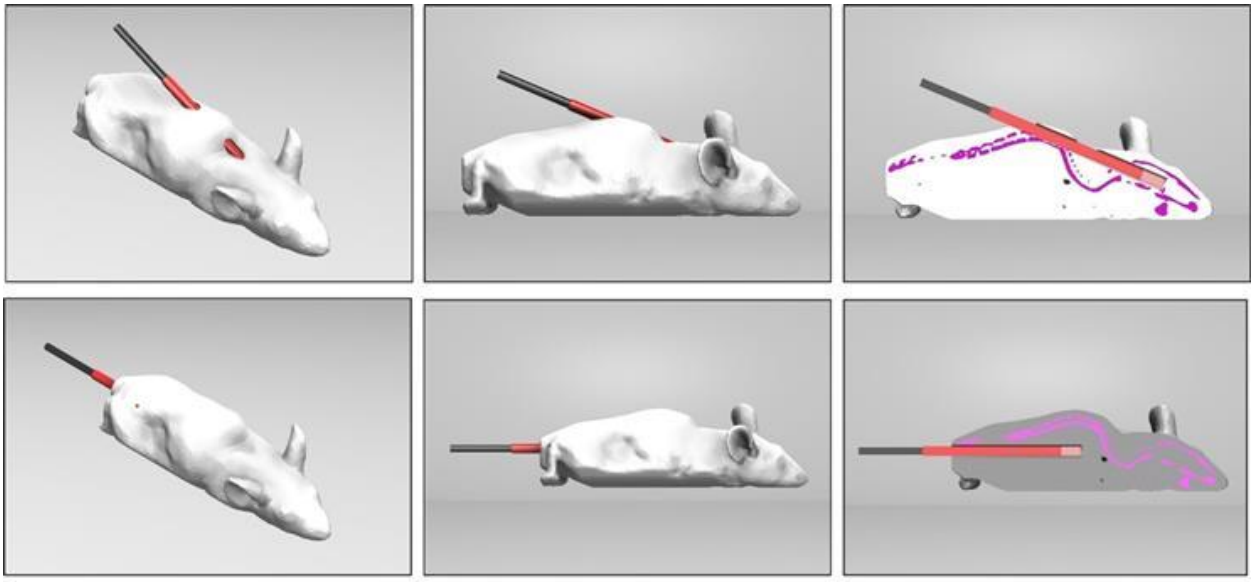

Figure 1. 3D printed heterogeneous mouse phantoms (ABS plastic for soft tissue, an ABS/CaTi03 mixture for the skeleton, lungs left as air gaps). Scintillator probe in the brain (top) and the abdomen (bottom) regions.

	end-to-end test results				
	Field	Field Configuration	Muriplan TPS Dose (Gy)	Scintillator Dose (Gy)	% Diff
Block	10 mm x 10 mm	Direct	200.155	200.39	0.12%
		Two Obliques fields (-50 and +50)	199.79	205.02	2.55%
	5 mm x 5 mm	Direct	198.63	197.85	-0.40%
		Two Obliques fields (-50 and +50)	200.132	202.94	1.38%
	3 mm x 3 mm	Direct	196.51	197.75	0.62%
		Two Obliques fields (-50 and +50)	200.168	204.45	2.10%
Mouse Brain	10 mm x 10 mm	Direct	198.98	203.82	2.38%
		Arc from -50 to 50	200.47	199.47	-0.50%
	5 mm x 5 mm	Direct	199.05	200.72	0.83%
		Two Obliques fields (-50 and +50)	200.47	195.91	-2.33%
Mouse Abdomen	10 mm x 10 mm	Two Obliques fields (-50 and +50)	501.76	518.02	3.14%
	5 mm x 5 mm	Two Obliques fields (-50 and +50)	502.62	508.35	1.13%

Figure 2. Direct, oblique and arc plans delivered to the centre of a WT1 homogeneous phantom and the brain and abdomen regions of 3D printed heterogeneous mouse phantoms (tissue, lung and bone).

% Difference (Diff) calculated as: $1 - \frac{TPS\ calculated\ dose\ (Muriplan)}{Measured\ dose\ (Scintillator)}$