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# Hybrid Optical-Gamma Camera for Intraoperative Imaging: A Flexible Phantom to Assess System Performance for Sentinel Node Detection

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## Background

A prototype small field of view (SFOV) hybrid optical-gamma camera (HOGC) has been developed by the Universities of Leicester and Nottingham [1]. It provides real-time, high resolution fused optical-gamma images highly suited to intraoperative procedures, such as sentinel node detection. The procedure commonly involves the administration of $^{99m}$Tc-nanocolloid, preoperative imaging and intraoperative localisation of node uptake followed by surgical removal of the sentinel node. High activity at the injection site and deep-seated sentinel nodes may pose a challenge in detecting the node. Therefore, we have developed standard methods for assessing the performance of the camera system in the clinical setting.

Figure 1: Photograph of the HOGC.

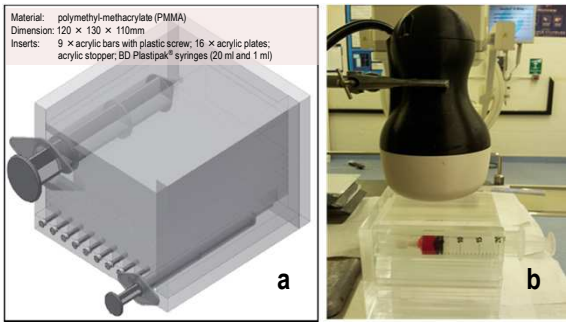


Figure 2: (a) 3D representation of the sentinel node phantom assembly and (b) the experiment set up during the detectability test.

## Method

A sentinel node phantom was developed to simulate the localisation of nodes in the presence of high injection site activity [2]. Scintigraphic imaging was carried out with different node depth (ND), node-to-injection site separation (NS) and node-to-injection site activity ratio (NIR). Detectability of the node by the camera systems was assessed by subjective visual assessment and quantification of the contrast-to-noise ratio (CNR).

$$\mathrm{CNR} = \frac{N_n - N_0}{\sigma_0}$$

where $N_n$ is the value of pixels in a node area, $N_0$ is the value of pixels in the background area and $\sigma_0$ is the standard deviation of pixel values in background areas.

## Results

The detectability study revealed that the HOGC could detect low-activity in nodes with the presence of high activity injection site with CNR values between 3 and 62 as shown in Figure 3. Visual subjective assessment of the images demonstrated the detection limits of nodes with NIR 1:100 and at depths below 45 mm with 25 mm of NS (Fig. 4). Comparative assessment of images acquired by the camera systems suggested that the HOGC was capable of detecting nodes at NS of 25 mm (Fig. 5).

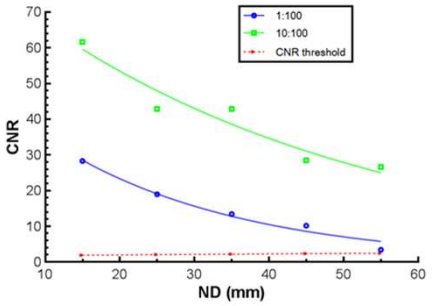


Figure 3: CNR values (NS of 25 mm) as a function of ND and NIR.

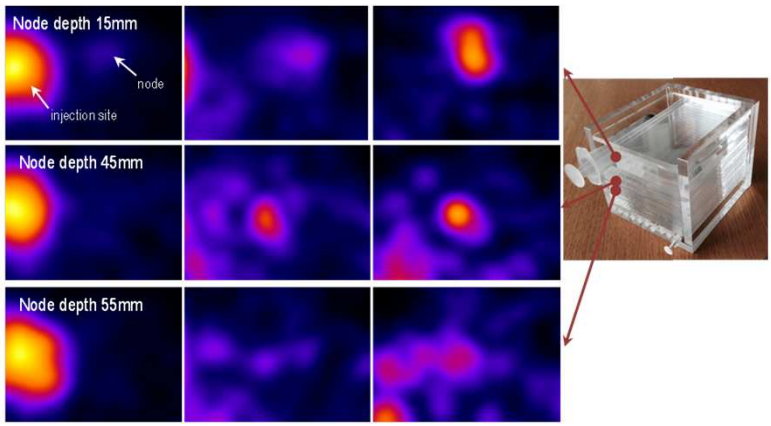


Figure 4: Image of the phantom with the presence of high activity at injection site acquired using HOGC. The node containing 0.2 MBq $^{99m}$Tc (NIR 1:100), at different depths and NS of 25 mm (left column), 35 mm (middle column) and 45 mm (right column). Acquisition time for each image was 60s.

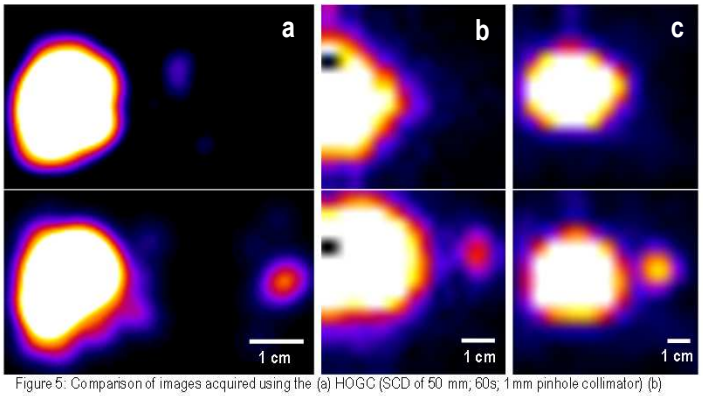


Figure 5: Comparison of images acquired using the (a) HOGC (SCD of 50 mm; 60s; 1 mm pinhole collimator) (b) CrystalCam (Crystal Photonics GmbH, Germany) (SCD of 20mm; 5s; high sensitivity parallel hole collimator) and (c) Nucline™ X-Ring-R (Mediso, Hungary) (SCD of 50 mm; 60s; low energy high resolution parallel hole collimator) at ND of 15 mm and NS of 25 mm (top row) and 35 mm (bottom row).

## Conclusion

A low cost phantom has been fabricated which provides a versatile method for the assessment of SFOV gamma cameras intended for sentinel node detection. The phantom is providing valuable information on the detection limits of nodes at depth within tissue.

**References:**
[1] J.E. Lees, S.L. Bugby, B.S. Bhatia, L.K. Jambi, M.S. Alqahtani, W.R. McKnight, A.H. Ng, A.C. Perkins. A small field of view camera for hybrid gamma and optical imaging. JINST2014;9:C12020.
[2] Ng AH, Clay D, Blackshaw PE, Bugby SL, Morgan PS, Lees JE, Perkins AC. Assessment of the performance of small field of view gamma cameras for sentinel node imaging. Nucl Med Commun 2015;In Press.

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