ABSTRACT

Surgery to remove breast cancer is performed almost 1,000 times a day in the United States. The current state-of-the-art surgery uses radioactive sources to indicate the center of the tumor and possibly a few points on the periphery as seen on mammography. Since such guidance is very coarse, tumor free margin is not achievable and a re-excision procedure is usually required. This approach provides no information about the margins of the tumor. Better radiation guidance could come from labeling all cancer cells directly with a breast tumor-seeking agent, such as CLR1404. The agent CLR1404 is taken up by breast cancer cells but not normal cells, labeled with radioactive ^{123}I could image the whole tumor not just points. ^{99m}Tc labelled nanoparticles locate sentinel lymph nodes. For the simultaneous detection and identification of photon energies 159 keV from ^{123}I and 141 keV from ^{99m}Tc, a radiation detector with high energy resolution, fine spatial resolution and sufficient sensitivity is required. This study involves the design, development, and characterization of such a handheld radiation detector. Following the design and integration of the detector, the main characteristics of the detector, such as energy resolution, photopeak efficiency and response at different source-to-detector distances were investigated experimentally. Energy resolution of the detector was found to be less than 10 keV (FWHM) at energies below 159 keV, which allowed resolving the radiation from the two radionuclides.

Energy spectra of the radioactive sources acquired experimentally were compared to those simulated in Monte Carlo N-Particle Transport Code (MCNP6/X) and good agreement was observed between two curves. The study is also targeted to give a contribution to the better localization of the SLNs and tumors by designing an optimum collimation geometry for the detector. Based on the simulations and experimental results, it was found out that by having a spatial resolution of 4.28±0.40 mm and sensitivity of 188.61±1.41 cps/MBq at 5cm source-to-detector distance, the collimated detector could meet the necessities of locating the deeply-seated SLNs that requires a detector with fine spatial resolution and adequate sensitivity. In overall; the detector was found to be promising for radio-guided surgery applications.