Differential Magnetometry to detect sentinel lymph nodes in laparoscopic procedures: static results

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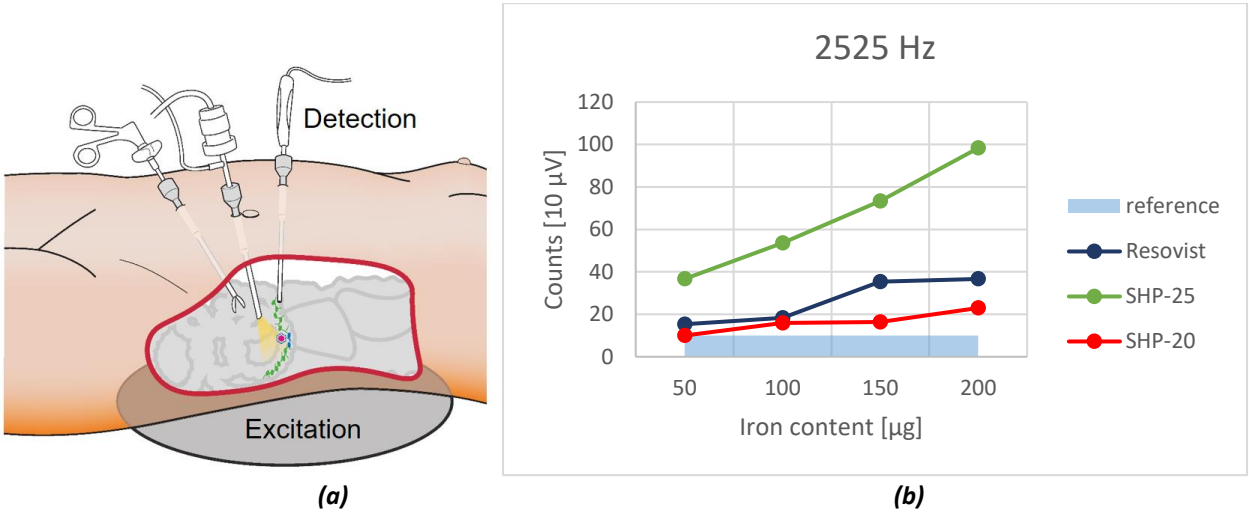
We present a novel laparoscopic probe for sentinel node biopsy, to facilitate minimally invasive surgery. Sentinel node biopsy is a procedure to analyze the lymph node status of cancer patients [1]. As a result, it can be determined if the tumor has metastasized, leading to personalized patient care.

Superparamagnetic iron oxide nanoparticles (SPIONs) are used as a tracer to identify sentinel nodes. The main advantages of SPIONs are their long shelf life, safe clinical use, and that they accumulate in the sentinel lymph nodes. The latter makes it possible to perform a pre-operative MRI scan, that can be used as surgical guidance. To locate SPIONs *in vivo* during open surgery, a magnetometer was developed [2]. However, the main drawback of this system is its sensitivity both to diamagnetic tissue and surgical instruments. The principle we use to locate sentinel nodes is Differential Magnetometry (DiffMag) [3]. In DiffMag, the nonlinear magnetic properties of SPIONs are exploited, enabling selective detection. However, our first handheld probe suffers from limited depth sensitivity, which does not meet the clinical need of pathologies where lymph nodes are located deep in tissue.

To meet the clinical demands of increased depth sensitivity, we propose a set-up in which the excitation and detection coils are mechanically separated, as shown in Figure (a). As a result, the size of the excitation coil can be increased and placed outside the body. The detection coil can then be made much smaller, and placed inside laparoscopic equipment. However, the main challenge of this set-up is that the detection coils can move with respect to the excitation coils. As a consequence, the detector signal is obscured by the excitation field, requiring continuous active compensation. We implemented this active compensation and tested it in a static set-up. The results are shown in Figure (b) for three different SPIONs. These first results are promising for sentinel node biopsies, since it is possible to detect small amounts of iron.

[1] Giuliano and Gangi, 2015. [2] Pouw et al., 2016. [3] Waanders et al., 2016.



(a) ***(b)***

*Figure – **(a)** A novel laparoscopic probe for sentinel node biopsies using our DiffMag technique with separated excitation and detection coils. **(b)** Static results, measured using the DiffMag protocol on samples of Resovist (Bayer Schering Pharma GmbH), SHP-25 and SHP-20 (Ocean Nanotech) containing different amounts of iron in a concentration of 5 mg/mL.*