



Optical Imaging of Fine Needle Aspiration Samples for specimen adequacy - a proof of concept study

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Introduction

Neck lumps are a very common problem and can represent a range of pathologies from benign to malignant. Two malignant pathologies that need to be excluded from a neck lump are a thyroid cancer and a head and neck squamous cell carcinoma (HNSCC). Thyroid lumps are common, this being one of the most common neck lumps a patient will present with. Epidemiology studies have shown the prevalence of palpable thyroid nodules is around 5% in women and 1% in men. High resolution ultrasound can detect thyroid nodules in up to 68% of individuals. The key clinical question is which nodules are benign and which are malignant, with up to 15% of thyroid nodules being a thyroid cancer. The incidence of thyroid cancer is raising exponentially. In Canada in 2017 there were 7100 patients diagnosed with thyroid cancer, of which 220 patients died from the disease. Worldwide the rates have increased significantly going from 95,030 incident cases globally in 1990 and 255490 incident cases in 2017 (1). This is thought to be due to several reasons. Primarily the use of more frequent high resolution medical imaging is picking up more lesions in the thyroid that would not have been clinically apparent. As a result there are far more patients being referred for investigation of their thyroid nodules. ATA guidelines suggest that thyroid nodules should have investigation with high resolution ultrasound and fine needle aspiration. This is the gold standard for diagnosis. Fine needle aspiration (FNA) is the gold standard for assessment of neck lumps. Inadequate results occur up to 20% of the time[2], requiring a repeat FNA at a different appointment. This causes significant stress for the patient and also has significant financial implications to the hospital in terms of resources and outpatient appointments.

Spectroscopy is a well established technique using optical imaging to identify lesions. It employs light and contrast, providing a scattering and absorption, measuring relative concentrations of oxy and deoxyhemoglobin as well as the presence of lipids and water content. We have developed an optical system performing spectroscopy and imaging using an optical needle developed to be compatible with the FNA workflow, see figure 1a and b. The practitioner can use standard FNA process with the newly developed optical needles embedded into a typical FNA metal needle. The aim of this project is to investigate the role of optical imaging using our new optical needle on FNA samples to assess specimen adequacy.

Methods and Materials

Animal models of papillary thyroid and squamous cell cancer were developed. 123 FNA samples were taken from both normal animal tissue samples (liver, lung) and animal tumour models using the newly developed optical needle. All needles were examined under the microscope and photographed pre and post FNA to assess for damage. FNA samples were processed either in CytoLit® fixative or by making a smear directly onto a glass slide. Spectroscopy output was then analyzed.

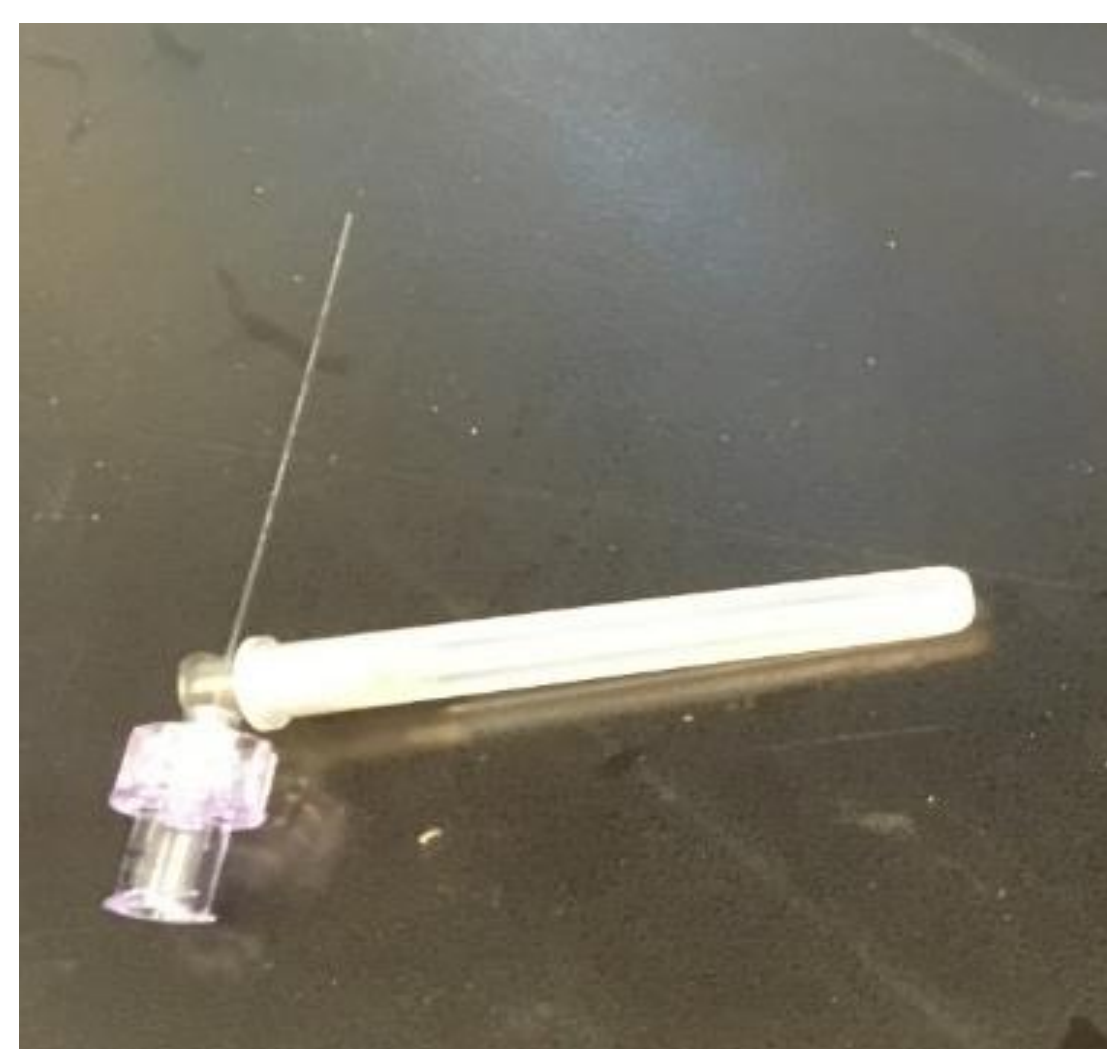


Figure 1a. Optical needle that fits inside standard FNA metal needle

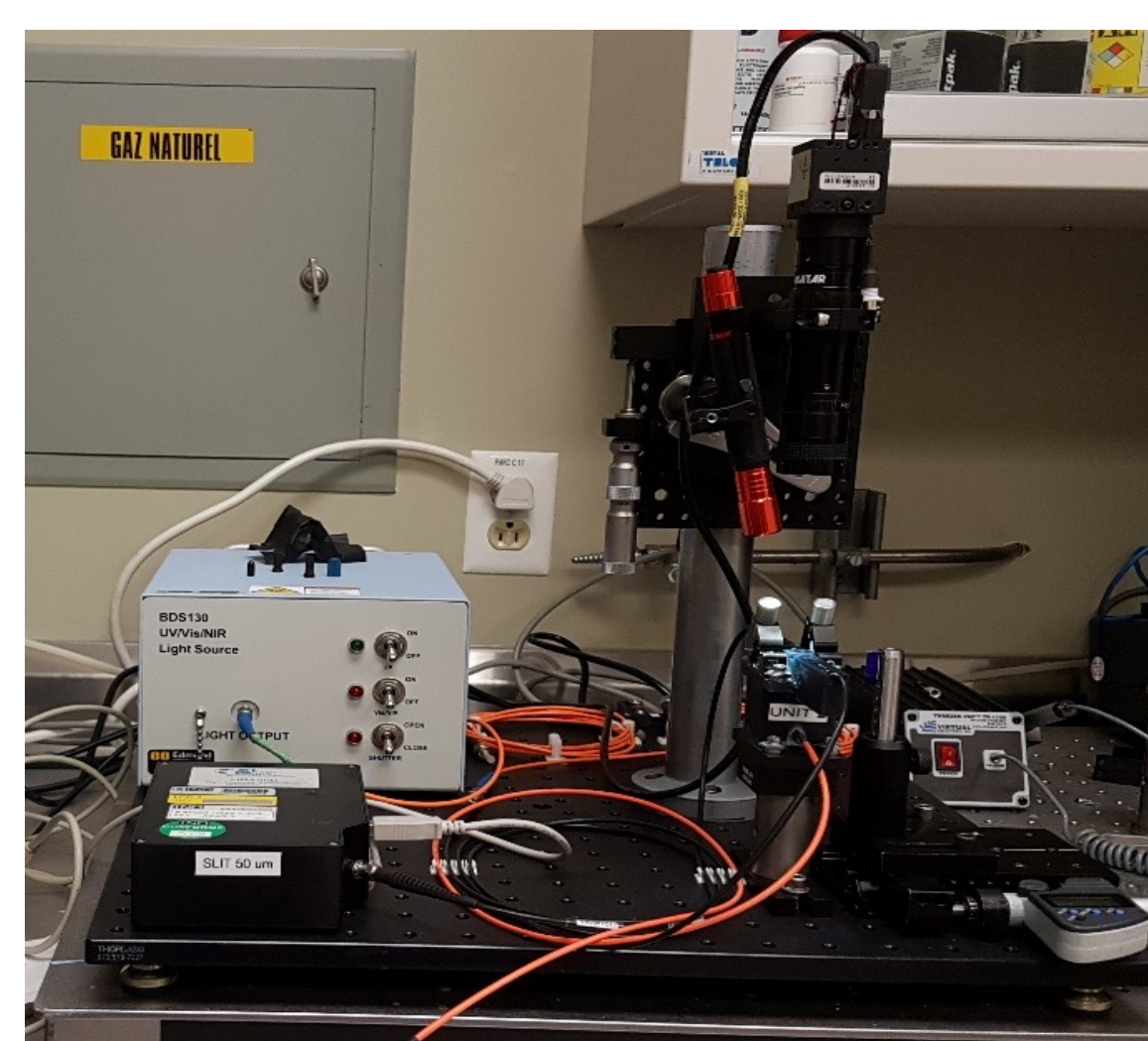


Figure 1b. Spectroscopy and imaging machine to image FNA needle

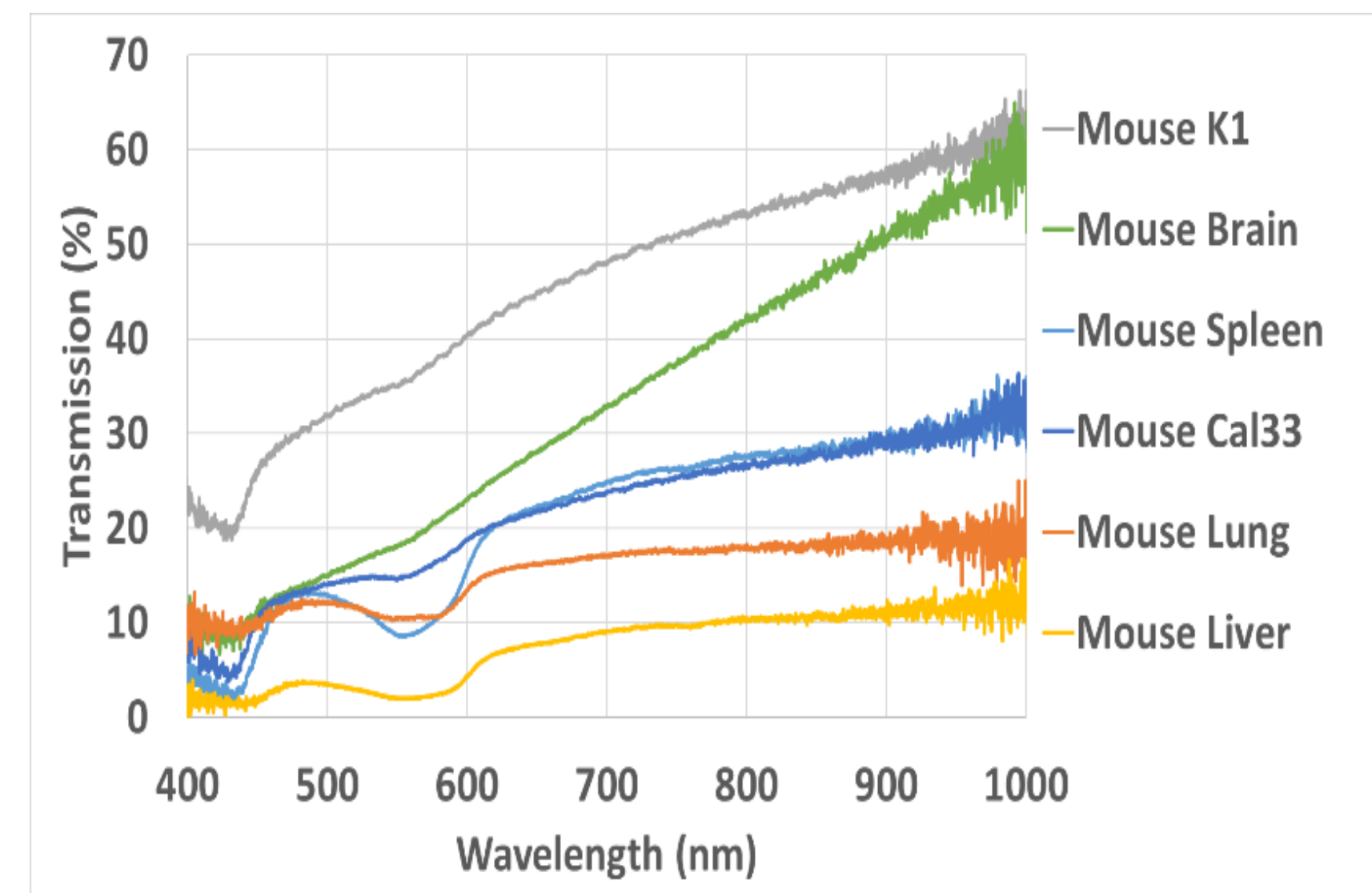
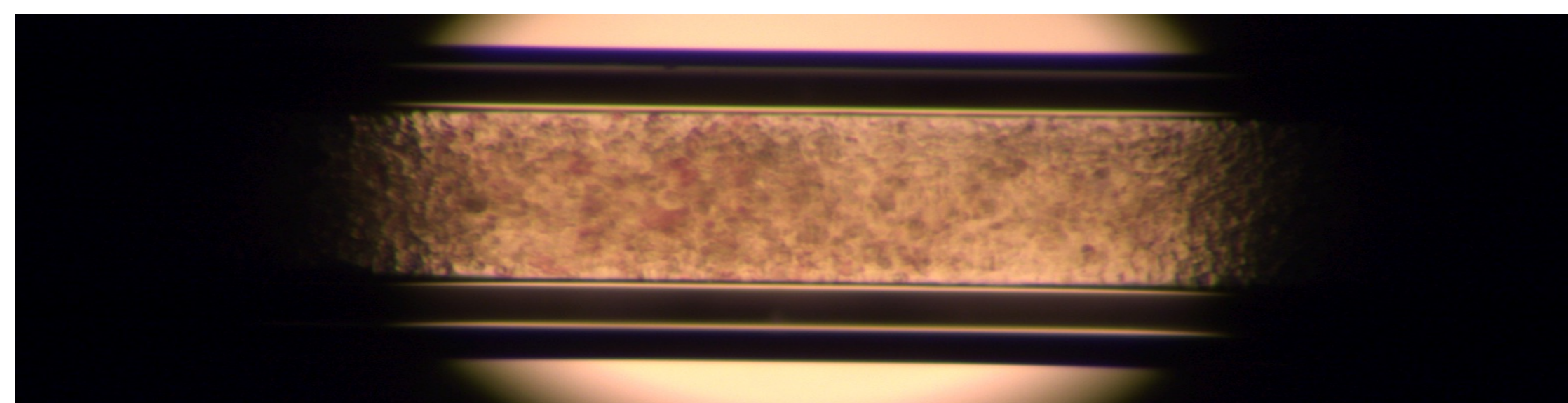
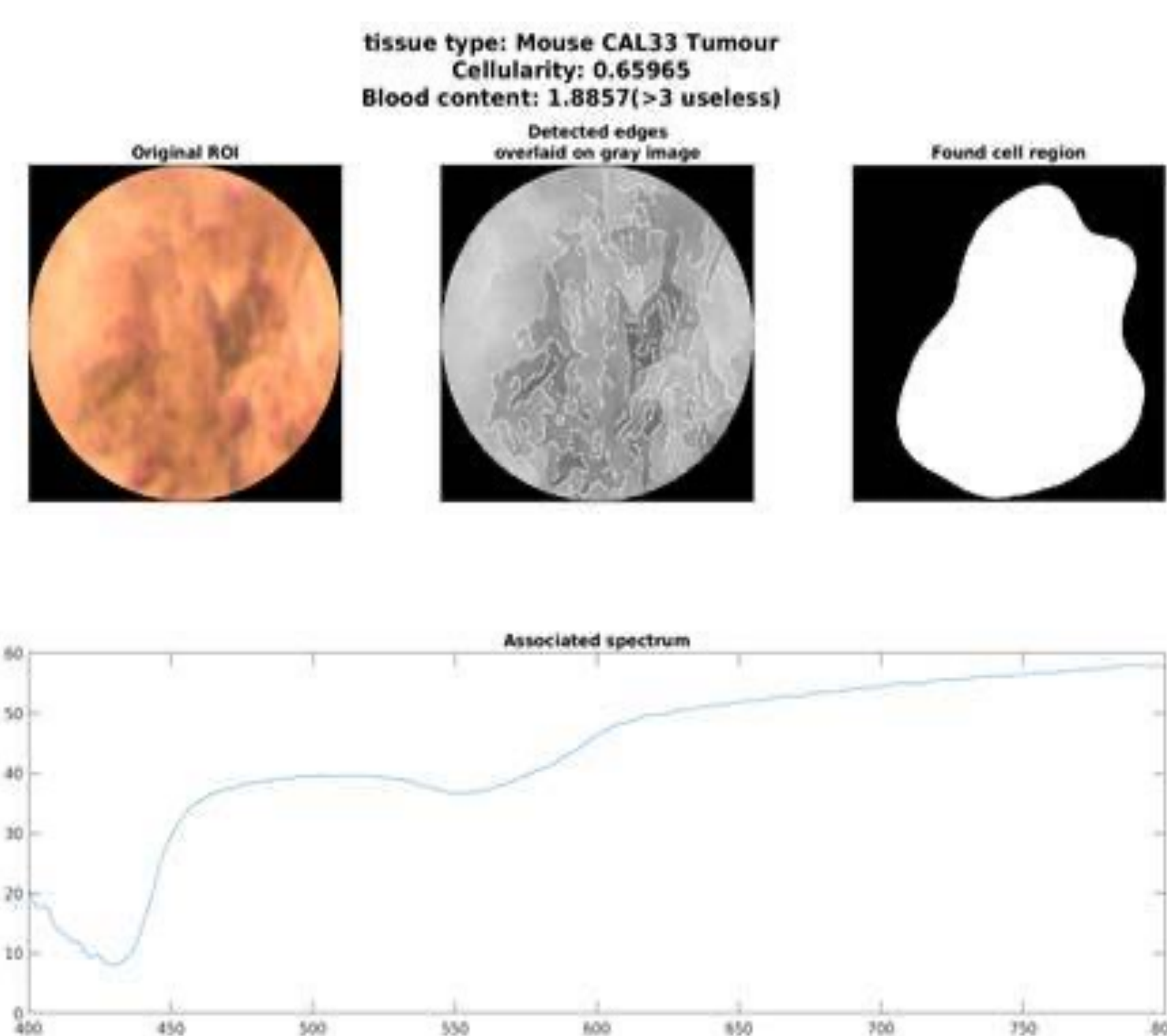


Fig 2. Spectroscopy output for different tissue and cancer type.



Figs 3 and 4. OS in patients treated surgically with curative intent who recurred with and without immunotherapy, and stratified by the use of systemic agents

Results

The optical needle had a 100% safety record with no breakage during the FNA procedure. The optical needle successfully picked up tissue when the FNA was performed, see figure 1c. Spectroscopy was performed on all samples. Output was different for each tissue type, and each cancer type, see figure 1d. First attempt of cellularity assessment has been performed by analyzing both images and spectra. Selection of analyzable samples were done via transmission spectra then cellularity evaluation was done using the image associated to the selected spectra (see Fig. 1e).

Discussion and Conclusions

This proof of concept study is the first to develop a new optical needle to improve the FNA workflow. The needle was shown to be safe, with no breakage. The preliminary spectroscopy output demonstrated a difference between tissue type and tumour type. Preliminary work needs to be continued to assess the cellular adequacy of samples processed with the system. Further, larger studies are now required to assess specimen cellular adequacy and compare against the current gold standard of a pathologists report.

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