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A Stereotactic Brain Biopsy Needle Integrating an Optical Coherence Tomography (OCT) Probe with Blood Vessel Detection in Human Patients

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Introduction

Stereotactic brain biopsies are a common neurosurgical procedure used predominantly to obtain histological diagnosis of brain pathologies. Intracranial haemorrhage is the most frequent complication related to this procedure and is associated with increased morbidity and mortality. We present a pilot study investigating a customised miniature Optical Coherence Tomography (OCT) probe integrated into a commercial stereotactic brain biopsy needle. OCT is a high-resolution optical imaging modality that uses reflections of low-power, near-infrared light to characterise tissue. The probe is combined with fully automated blood vessel detection software based on speckle decorrelation to provide real-time feedback as the needle tip encounters a blood vessel.

Methods

We demonstrate the use of such a needle intraoperatively for the first time in humans. A total of 167 superficial blood vessel and control measurements were obtained in 11 patients undergoing craniotomies for various pathologies. Deep blood vessel measurements were also acquired in 3 patients. Superficial blood vessel measurements were obtained by directly placing the probe over cortical vessels exposed during craniotomy and validated against intraoperative photographs. Deep vessels were targeted using preoperative MRI and frameless stereotactic surgical navigation.

Results

For the superficial vessel measurements, the probe demonstrated a sensitivity of >88% and specificity >98% for the detection of blood vessels >500microns in diameter. For the deep vessel measurements, the probe was able to detect a blood vessel appropriately on all three occasions.

Learning Objectives

By the conclusion of this session participants should be able to

1) appreciate the potential for OCT applications in Neurosurgery

2) understand that probe based neurosurgery major risk factor is haemorrhage

3) understand the high resolution nature of OCT and its ability to provide real time information

Conclusions

This pioneering study demonstrates OCT detection of blood vessels in human patients in real-time, integrated with current Neurosurgical practices. This work opens the possibilities of further studies using OCT to detect blood vessels in probe based Neurosurgery to minimise the risk of haemorrhage from such procedures.