APPLICATION FOR A GOSHCC SURGICAL SCIENTIST PHD STUDENTSHP

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1. Title.

Minimally invasive thermal lesioning of epileptogenic foci in the paediatric brain

2. Portfolio summary.

**Aims:** Increase the accuracy and outcome of minimally invasive thermo ablative therapies for epilepsy patients using modelling and image guidance.

**Background:** Epilepsy is one of the most common chronic neurological conditions and affects 58,000 children in the UK. Whilst many children achieve good seizure control with medical therapy, a significant subset have ongoing drug resistant seizures. In this group, epilepsy surgery can be an effective, albeit invasive treatment with 50-60% of such children being rendered seizure free.

Surgery is often preceded by the implantation of intracranial electrodes followed by monitoring to better characterise the seizure onset zone. This also provides the opportunity for treatment using these electrodes by applying a current to specified contacts to produce a local thermal lesion. Recent technological advances have also allowed the minimally invasive implantation of laser catheters into epileptogenic foci in order to produce thermal lesions. These lesions can be imaged in real time using MRI thermography.

The outcome of these procedures has however been variable, in part as the resulting lesions are highly localised and poorly defined. The aim of this project is to develop methodology for modelling these thermal lesions and thus determine the optimal lesioning strategy. This would allow the production of a well-defined thermal dose which is individualised using modelling of electrical and thermal fields and updated based on intra-operative image guidance. This is particularly relevant due to the imminent arrival of a state-of-the art neurosurgical intraoperative MRI suite at Great Ormond Street Hospital.

**Proposed methodology to be adopted:**

There are two main elements that will be used. Firstly, we will model electric field distributions based on individual subjects MRI scan, this will be combined with a thermal solver that can calculate a 3D map of the thermal dose received by a patient. We will perform experimental validation using a test object and 3D MRI based thermal measurements along with traditional temperature measurements at a number of locations. In addition patient results of thermocoagulation will be compared to model predictions. Following this validation treatment protocols in an individual based on the definition of a desired thermal dose to a given brain region can be made. This would allow for individualised targeted therapy and could inform implantation strategies that allow for thermocoagulation to be used as a minimally invasive surgical procedure.

Phase 1: Adapt existing electrical and thermal solvers for the purpose of modelling the thermal dose received by tissue during ongoing thermocoagulation procedures. Thermal
doses can be compared to the resulting brain lesion determined by post-operative MRI. Develop MRI-based thermal monitoring that can be performed in conjunction with intracranial EEG, or conversely test newly available MRI translucent intracranial EEG implants.

Phase 2: Develop a model of thermal dose delivery based on optimising the delivery of stimulation to the target brain region. The implementation will be tested under image guidance in a model system (e.g. porcine brain). Where the target is well defined electrode placement may be also be optimised to allow for optimal thermal dose delivery.

Phase 3: Clinical pilot study of the methodology developed. In patients selected through the clinical program for thermal lesioning, these methodologies will be employed to plan optimal placement of CE licensed thermal lesioning devices and to guide lesioning strategies.

**Skills to be achieved by the PhD trainee:** Knowledge of paediatric epilepsy surgery and thermocoagulation procedures. MRI thermography imaging and modelling skills. Computer based thermal modelling. Planning and implantation of intracranial stereoEEG electrodes. Planning and implantation of intracranial laser catheters. Robotic neuronavigation techniques

**Relevance to the area of paediatric surgery:** Epilepsy surgery is one of the most important treatments for drug-resistant epilepsy in children, reflected in the establishment of the national Children Epilepsy Surgery Service. A major output of this project is to develop tools that predict outcome and determine optimal surgical resections.

**References:**
Radiofrequency thermocoagulation of the seizure-onset zone during stereoelectroencephalography.

Magnetic Resonance Imaging-Guided Laser Interstitial Thermal Therapy for Treatment of Drug-Resistant Epilepsy.

Stereoelectroencephalography-guided radiofrequency thermocoagulation in the epileptogenic zone: a retrospective study on 89 cases.

Hypothalamic hamartomas: optimal approach to clinical evaluation and diagnosis.