The Role of Preoperative Functional MRI in Brain Tumour Resection by Awake Craniotomy: Initial Experience in 20 Glioma Patients

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Neurosurgical resection is often the primary method of treatment for brain tumour patients diagnosed with glioma. There are increased surgical risks when tumours are adjacent to the "eloquent cortex" responsible for processing sensory, motor, and language function. To preserve these areas and subsequently minimize post-operative behavioural deficit, an awake craniotomy (AC) is performed with invasive intraoperative mapping of brain activity by electrical stimulation. Prior to surgery, preoperative functional magnetic resonance imaging (fMRI) can be used noninvasively to generate brain activity maps that assist with surgical planning (i.e. determine craniotomy extent, identify safest surgical entry point, denote high-risk resection areas) [1]. Based on fMRI results, the surgeon may even suggest a more suitable treatment option (e.g. craniotomy performed with patient asleep, chemotherapy, radiation therapy), thereby limiting the number of patients undergoing an AC. The benefits afforded by preoperative fMRI can play a significant role in surgical management to provide optimal treatment. Here we report our predominantly positive experience with preoperative fMRI for the treatment of gliomas towards encouraging its extended use for this specific patient group.

Methods: Our development of an fMRI-compatible tablet has enabled the use of a wide range of behavioural tasks for mapping eloquent cortex [2]. For example, we can program tasks on the tablet system that incorporate fine motor control, reading, writing, and/or drawing. This becomes substantially useful for language mapping because it allows us to assess multiple domains of language function and identify critical language areas. In our study, language and motor tasks were administered during a 1-hour fMRI session a week prior to surgery. Activation maps were generated for each task and carefully considered in the surgical planning process. Intraoperative mapping results were video documented and used to validate fMRI activation maps. Validation was performed via a spatial registration of the craniotomy window with MRI surface reconstructions such that the degree of overlap between fMRI activations and intraoperative mapping results could be measured.

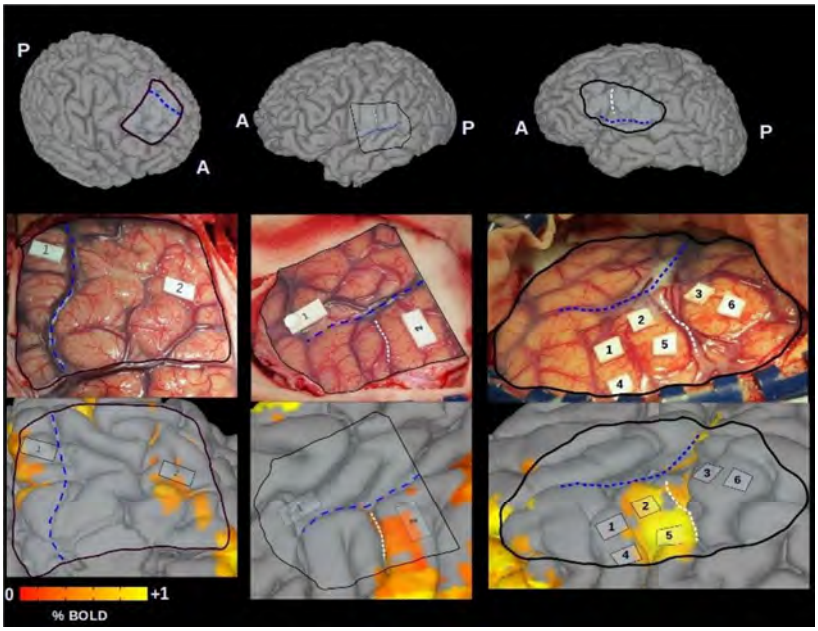

Figure 1: Word generation task validated in three glioma patients. (Left) Good overlap with sites 1 and 2 of the prefrontal cortex. (Middle) Good overlap with site 2 along the motor cortex. (Right) Good overlap with sites 2 & 5 along the motor cortex. The blue and white dotted lines represent orienting landmarks and the surgical entry points, respectively.

Results: Thus far, 11 male and 9 female glioma patients (WHO grades I-III) have undergone preoperative fMRI. The patients ranged in age from 18 to 70 years (mean 40.1), 4 of which were left-handed. Nine patients presented with right hemisphere lesions, and the remaining were left hemisphere lesions. Following preoperative fMRI: 11 patients underwent an AC with intraoperative mapping, 1 patient underwent surgical resection asleep, 3 patients remain scheduled for an AC, and 5 proceeded with alternative treatment options (e.g. chemotherapy). In 5 of the 12 surgical cases, preoperative fMRI influenced surgical decisions by dictating the surgical approach (i.e. optimal surgical entry point, preservation of gyri) and surgical technique (i.e. asleep versus awake craniotomy). Functional MRI maps for a word generation task were validated within a 5 mm radius when compared with intraoperative mapping of the same task (Fig 1). Patients were presented with a letter and asked to generate multiple words beginning with that letter. When performed in the MRI scanner, written responses were recorded on the tablet (overt language production). In the operating room a verbal response was recorded.

Discussion: The utility of preoperative fMRI led to an impact on surgical management of more than half the total patient group (not including 3 patients awaiting surgery), the majority of which were patients with low-grade glioma (LGG). LGG are relatively slow-growing lesions and patients with LGG often experience fewer behavioural symptoms [3]. It is therefore ideal to have a preoperative fMRI that can help determine the surgical risks before an invasive treatment is undertaken. Functional MRI maps need to be reliable to be considered in any decision-making involving patient management; to date our fMRI results have agreed well with intraoperative mapping data. Figure 1 shows positive overlap of activations within the prefrontal and motor cortex which are known to be involved in speech articulation and the active use of facial muscles when speaking, respectively.

Conclusion: We have demonstrated that preoperative fMRI is a useful tool to assist with the surgical management of glioma patients. Preliminary results are encouraging and patient recruitment is ongoing. This research lays the ground-work for further investigations of short-term and long-term patient outcomes, including patient quality of life and patient survival.

References: 1. Rutten, GJM., Ramset, NF., et al. (2002) Development of a functional MRI protocol for intraoperative localization of critical temporoparietal language areas. *Annals of Neurology.* 51(3):350-60. **2.** Tam F, Churchill NW, Strother SC, Graham SJ. A new tablet for writing and drawing during functional MRI. Hum Brain Mapp. 2011; 32:240-48. **3.** Sanai, N., Chang, S., and Berger, MS. (2011) Low-grade gliomas in adults. *Journal of Neurosurgery.* 115(5):948-65