True Intraoperative Functional MRI: A Feasible Technology for Intraoperative Brain-Mapping

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Objective

Paradigms for functional MRI are generally *active* in nature, limiting the method to awake and cooperative patients and to the preoperative period. However, a novel *passive* fMRI paradigm for localization analysis of the sensorimotor cortex allows functional analysis of neurologically impaired and even anaesthetized patients. Technologically this *passive* paradigm relies on peripheral electrical nerve stimulation (median and/or tibial) through newly developed hardware attached to the patients wrist and ankle, dubbed StimuLink.

The present study evaluates the feasibility of intraoperative fMRI in anaesthetized patients undergoing brain tumour resection utilizing this novel paradigm in1.5 Tesla and 0.3 Tesla scanners.

Methods

In 4 anaesthetized patients with centrally localized lesions intraoperative fMRI scans were acquired employing an intraoperative 1.5 Tesla MR scanner (Siemens Espree). Additionally, 2 patients with centrally located brain tumours were evaluated intraoperatively employing an open 0.3 Tesla unit (Hitachi Airis). In both setups StimuLINK was employed as paradigm. The functional data were analyzed statistically, co-registered with the Talairach space and validated by electrophysiology.

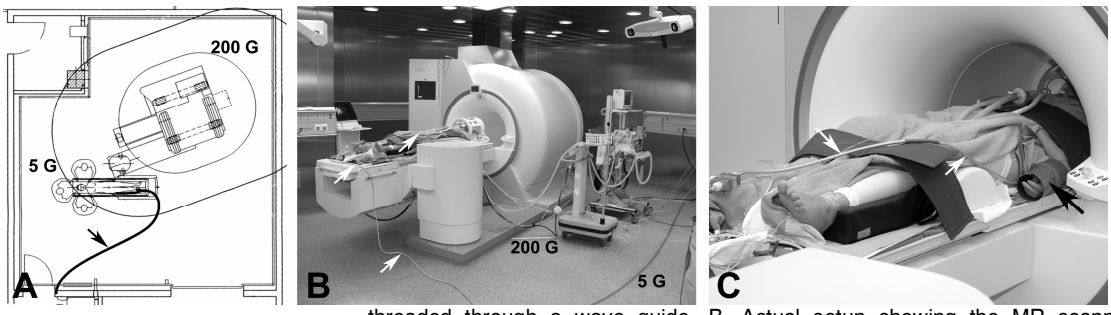

Figure 1. Operating room setup for intraoperative fMRI. A. Schematic layout of the radiofrequency-shielded operating room depicting the position of the MR scanner, the operating table, and the conductor (arrow) that is threaded through a wave guide. B. Actual setup showing the MR scanner, respiration and monitoring equipment, and the camera of the ceiling mounted neuronavigation system. The conductor (white arrows) leads to the stimulation sites. C. The patient is positioned for scanning with the conductor (white arrows) and shielding tube (black arrow) in place. B & C depict the scenario just after induction of anesthesia and head fixation before draping for a better visualization.

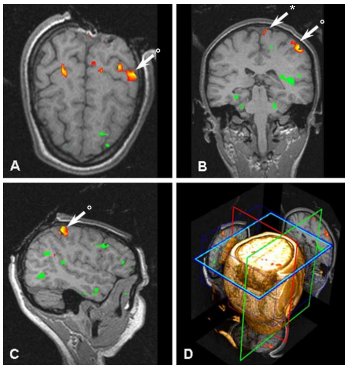

Figure 2. Intraoperative 1.5 T fMRI of Patient No.3 after removal of the cavernoma (display of fMRI activity with the co-registered T1-weighted MPRAGE sequence; A: axial; B: coronal; C: sagittal). The white arrows point to the activated cortex due to median nerve stimulation, the black arrow to the activation due to stimulation of the tibial nerve.

Results

Utilizing this passive fMRI paradigm, the sensorimotor cortex could be identified in 3 of the 4 patients under 1.5 Tesla and in both patients under 0.3 Tesla. The image quality was superior in the high-filed units; however, susceptibility artefacts were less prominent in the 0.3 Tesla data. Susceptibility artefacts influenced image quality marginally. In the 1.5 Tesla data, we observed a significant change in signal intensity in the course of the operation and detected regularly an inverted BOLD-signal response, which may be caused by an inhibition of cerebrovascular autoregulation under total intravenous anaesthesia.

Conclusion

We could demonstrate the feasibility of this method to identify the sensorimotor cortex in anesthetized patients in the surgical setup employing both 1.5 and 0.3 Tesla MR-scanners. Further studies will have to evaluate the BOLD-signal characteristics under anaesthesia and the clinical impact of intraoperative fMRI.