Functional MRI and calculation processing: considerations on preliminary experience about intra-operative validation by electro-stimulation

Neurol Sci
DOI 10.1007/s10072-015-2255-5

LETTER TO THE EDITOR

Functional MRI and calculation processing: considerations on preliminary experience about intra-operative validation by electro-stimulation

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Received: 13 January 2015 / Accepted: 13 May 2015

Dear Editor,

We recently reported our experience on functional mapping for calculation processing [1–3]. The numerical processing is a crucial function in daily life and its preservation can be achieved in patients undergoing neurosurgery. Indeed, it is well known the role of functional magnetic resonance imaging (fMRI) in surgical planning in patients affected by a brain tumor located in an eloquent area [4, 5] as well as in the detection of structural and functional brain changes in patients with Parkinson's disease [6]. However, the fMRI reliability to detect functional sites for calculation in these patients is unclear because we are currently lacking of data on the correspondence between preoperative fMRI and intra-operative findings. A 47-year-old male patient affected by a small right parietal brain tumor recently came to our attention (Fig. 1a, b). Preoperatively, the patient underwent fMRI (3T Ingenia Philips scanner) with 16-s blocks of single-digit additions or multiplications and a control counting task. We focused on both one-digit addition and multiplication because they are the most basic of calculation tasks and their sparing is intuitively essential to perform higher order calculation. The fMRI showed some functional sites for calculation in the right superior lobule of the parietal cortex: three sites involved in addition (Fig. 1c, d) were shown just anteriorly [1, 2] and laterally [3] to the tumor; 1 site involved in multiplication (Fig. 1e) was shown just medially to the tumor. The patient then underwent the surgical resection of the parietal tumor. The approach and intra-operative mapping were performed as previously described [1, 2]. The same calculation tasks used for fMRI were administered during surgery. Remarkably, we intra-operatively noted that the parietal cortical areas of the superior lobule involved in both multiplications and additions detected with electro-stimulation perfectly corresponded to those preoperatively shown by fMRI (Fig. 1f). The correspondence was both for sites and involved functions. Two considerations arise from our report: first, the potential capacity of fMRI to predict sites functional for calculation then detectable with intra-operative electro-stimulation. This concordance between preoperative and intra-operative findings has never reported in literature so far. Even if we must keep in mind that calculation processing is a complex function not completely understood yet, our present experience, and previous studies [1, 2] suggest that some cortical sites can be identified as "critical". Now, we present the first report showing that the same "critical" cortical sites are both activated at fMRI and localized by intra-operative mapping. It is still unclear whether these "critical" sites are also "essential" for involved function. The capacity of interfering with function by electro-stimulation of these sites theoretically supports the hypothesis of a "crucial" role in calculation processing. However, further studies on this key topic are needed. Second, functional mapping has proved a powerful tool to validate fMRI findings of calculation. This issue implies that intra-operative electro-stimulation can be helpful in improving our

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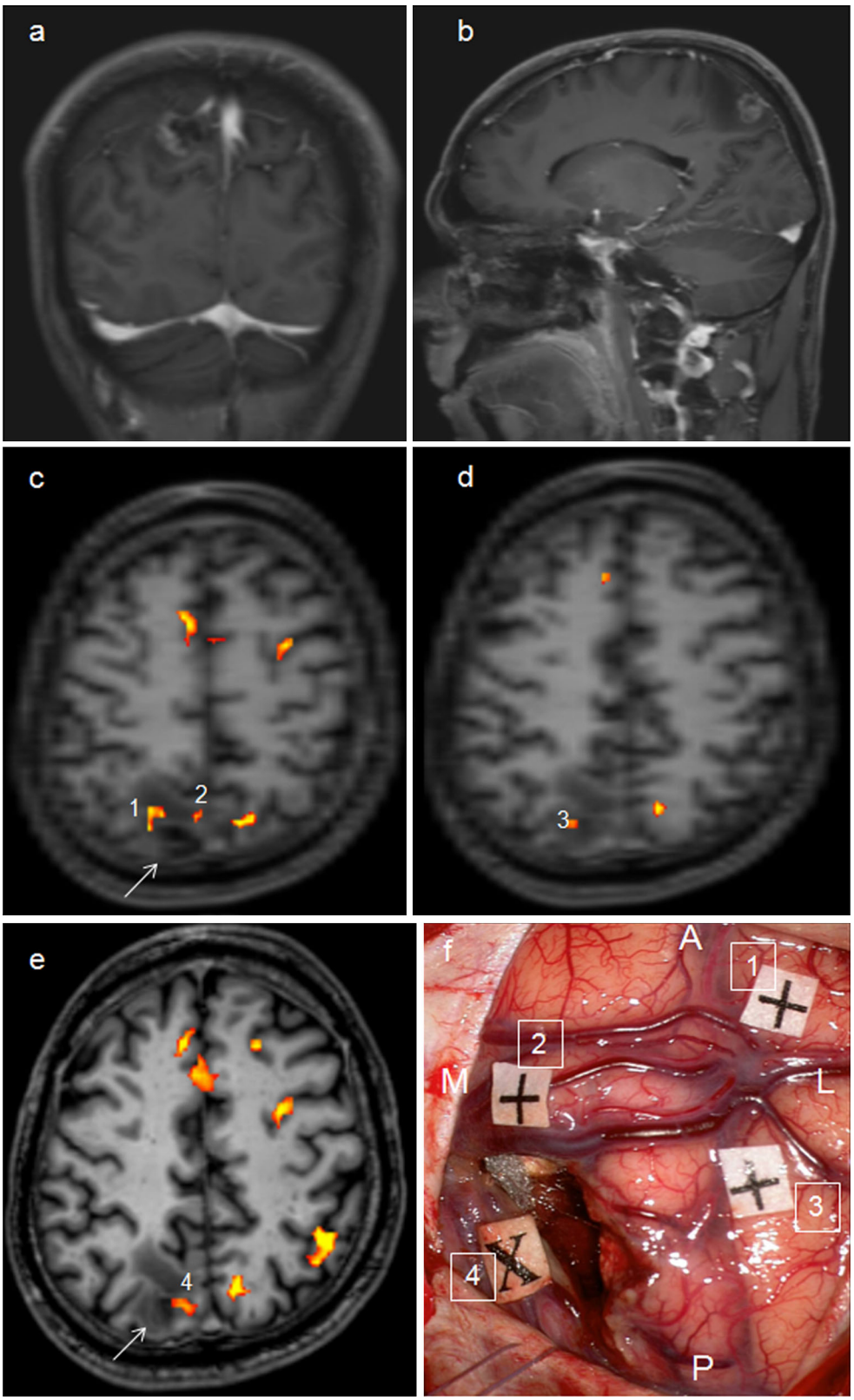
Published online: 17 May 2015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◀**Fig. 1** Pre-operative functional MRI for calculation and intra-operative picture of a patient's brain with a 1-cm-sized parietal brain tumor. **a**, **b** Sagittal and coronal T1-weighted images after gadolinium administration. **c**, **d** Addition fMRI activations; **e** multiplication fMRI activations; **f** intra-operative images showing cortical sites positive at electro-stimulation (+, addition; ×, multiplication) (*A* anterior, *P* posterior, *M* medial, *L* lateral). The picture shows the overlapping between sites detected at preoperative fMRI around the tumor (*white arrow*) and sites detected at intra-operative electro-stimulation (for addition: anterolateral, anteromedial, lateral to the surgical cavity—*1*, *2*, *3*, respectively; for multiplication: medial to the surgical cavity—*4*)

knowledge not only about calculation processing network but also about the reliability of related imaging modalities.

Again, a single case of such a correlation is really not sufficient to prove the reliability of fMRI in calculation. The purpose of this brief report is to share our initial experience with both neurological and neurosurgical community to encourage the clinical research in this setting. Indeed, only large series with homogeneous surgical and radiological methods could assess the reliability of this promising approach in the clinical practice.

Conflict of interest The corresponding author states that the authors of the manuscript have no conflict of interests concerning the materials or methods used in this study or the findings specified in this paper. Moreover, no funding was received for this study.

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