Introduction

Functional imaging

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The evolution of neurosurgery has in many ways paralleled the evolution of technology used to image the nervous system. It is no exaggeration to say that safe and effective modern neurosurgery has largely been made possible by advances in structural neuroimaging that permit evermore precise delineation of normal and abnormal anatomy in the brain and spine. Within the last 2 decades, and in particular since the turn of the century, structural imaging is increasingly being complemented by imaging approaches that allow the neurosurgeon to observe and measure neural activity and connectivity. These functional imaging techniques span multiple modalities and can assist the neurosurgeon in diagnosing neurosurgical conditions, selecting appropriate patients for neurosurgical intervention, performing preoperative and intraoperative brain mapping to avoid damage to eloquent areas of the brain during surgery, and assessing neuroplasticity during postsurgical recovery. In effect, the marriage of structural and functional imaging is ushering in a new era of neurosurgical practice that could be called—to borrow terminology from the technology world—Neurosurgery 2.0.

It is, of course, impossible to cover all neurosurgically relevant aspects of functional imaging in a single issue of *Neurosurgical Focus*. Our aim is simply to provide an effective introduction to several functional imaging approaches in the neurosurgical armamentarium. The articles are ordered in such a way as to take the reader from current and established applications of functional

imaging to emerging applications to exciting preclinical work with translational potential.

We begin with a review by Abdullah et al. summarizing the published literature on diffusion tensor imaging (DTI) as an adjunct to the resection of gliomas. In many centers, DTI acquisition is now a routine component of preoperative MRI in patients with brain tumors, and DT images are widely used for planning the surgical approach and during intraoperative neuronavigation. This paper is followed by a review on functional imaging in the setting of intracerebral hemorrhage by McDowell et al., which emphasizes its role in assessing the evolution, prognosis, and pathophysiology of this common neurosurgical condition. Takahashi et al. introduce the technique of navigated transcranial magnetic stimulation (nTMS), and they review its application to presurgical motor mapping in patients with perirolandic brain tumors. By critically assessing 11 published series in which nTMS mapping was performed, the authors show that the accuracy of nTMS for motor mapping compares favorably with both intraoperative direct cortical stimulation and functional MRI (fMRI).

The next 2 papers represent single-institution experiences with selected applications of functional imaging to specific neurosurgical disorders. Sommer et al. present a sizable series of patients with lesional extratemporal epilepsy in whom resection was guided by integrated DTI and fMRI. The superb seizure outcomes they report speak to the value of multimodal functional imaging in preventing neurological deficit while maximizing lesion resection. Similarly, Conti et al. describe their successful multimodal imaging approach to stereotactic CyberKnife radiosurgery, in which they combine not only fMRI and DTI but also nTMS to shape the treatment plan.

Three retrospective series follow on the specific application of fMRI to preoperative sensorimotor and language mapping. Kundu et al. examine whether postoperative language outcomes after tumor surgery can be predicted by the proximity of tumors to preoperative language activations in the Broca and Wernicke areas. Voss

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et al. take the theme of language mapping further; they show how fMRI can identify secondary language centers, such as the supplementary and presupplementary motor areas, which may impact planning and outcome in intra-axial brain tumor surgery. Gallagher et al. apply fMRI to mapping sensorimotor function and language in patients with vascular lesions.

The issue concludes with 2 papers pointing to the future of functional imaging. Spader et al. introduce the novel mcDESPOT MRI acquisition technique, which provides neurosurgeons with the capacity to accurately quantify myelin content within specific regions of the brain. They provide preliminary clinical data to show the utility of this technique in identifying the seizure focus in pediatric epilepsy, and they address its potential advantages over other approaches to white matter imaging. Finally, Patel et al. provide exciting preclinical data—in both animals

and humans—to suggest that optical imaging of intrinsic hemodynamic signals may be able to predict and localize seizures with remarkable accuracy.

Functional imaging is now an integral part of modern neurosurgery and will assume ever-increasing importance as our specialty evolves. We hope that the collection of papers in this issue of *Neurosurgical Focus* will provide readers with useful information about how functional imaging can be incorporated into neurosurgical patient care and that it will stimulate research into novel applications of functional imaging in the diagnosis and treatment of neurosurgical illness.

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Disclosure

The authors report no conflict of interest.