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# Enhancing surgical precision and patient outcomes with fMRI

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Shiga University of Medical Science (SUMS) in Ōtsu, Shiga Prefecture, Japan, is known for its advanced technology in neurological imaging and neurosurgery. We often use functional magnetic resonance imaging (fMRI) to scan patients with malignant gliomas who often struggle to understand and perform tasks.

fMRI is essential for functional mapping prior to awake brain surgery where the patient remains conscious during the operation so the surgeon can precisely map and preserve critical brain functions while removing tumors. During an fMRI session, it's often unclear whether patients can perform tasks correctly or if brain activations are task related. Typically, clinicians have to analyze the data after the scan using offline software, only determining the success of the fMRI exam after the analysis is complete.

We installed the SIGNA™ Architect with BrainWave imaging software, an analysis and visualization tool for functional brain image data, to address this challenge. Together, they solve the fMRI challenge by providing real-time feedback on task-related brain activity directly on the console, allowing clinicians to instantly assess the success of the examination.

In addition, we recently implemented the MR 30 for SIGNA™ upgrade, adding AIR™ Recon DL to 3D and motion-insensitive PROPELLER imaging. At SUMS, AIR Recon DL 3D has been useful for acquiring T1 volumetric images, which are acquired for fusion but not directly used in fMRI. In the future, applying deep learning to fMRI imaging could enhance statistical robustness or shorten scan times.

## Improving surgery preparation with fMRI

At SUMS, most fMRI studies are performed two to three days before surgery, allowing one to two days for data analysis and interpretation. These images support functional brain mapping and surgical planning, as well as facilitate collaboration between the radiologist and neurosurgeon.

During an fMRI session, the technologist performs the imaging, while the neurosurgeon monitors task performance and resulting brain activations. The brain mapping process relies on a variety of task-based activations, including finger tapping or opening and closing the hand to identify motor area activations. We also use “Shiritori,” a Japanese word-chain game, for language area activations. Hand movements and language are key functions for patients after surgical

SIGNA Architect 3.0T		
	FLAIR	T1 FSPGR + contrast
TR (ms):	12000	6.7
TE (ms):	126	2.11
FOV (cm):	22	22
Slice thickness (mm):	5	0.89
Frequency:	256	384
Phase:	192	320
NEX:	1	1
Scan time (min.):	2:37	6:52

procedures. Functional brain mapping with fMRI before surgery is critical to improving a patient's prognosis and preserving their quality of life.

BrainWave enables processing, analysis, 3D rendering and display of results from blood-oxygen-level-dependent (BOLD) MR scans. BrainWave PA enables interactive viewing and editing of fMRI data. We use a 48-channel head coil to achieve better SNR, given the small BOLD signal, a measure that detects changes in brain activity by observing variations in blood flow and oxygen levels in different regions of the brain. This approach also helps improve spatial resolution.

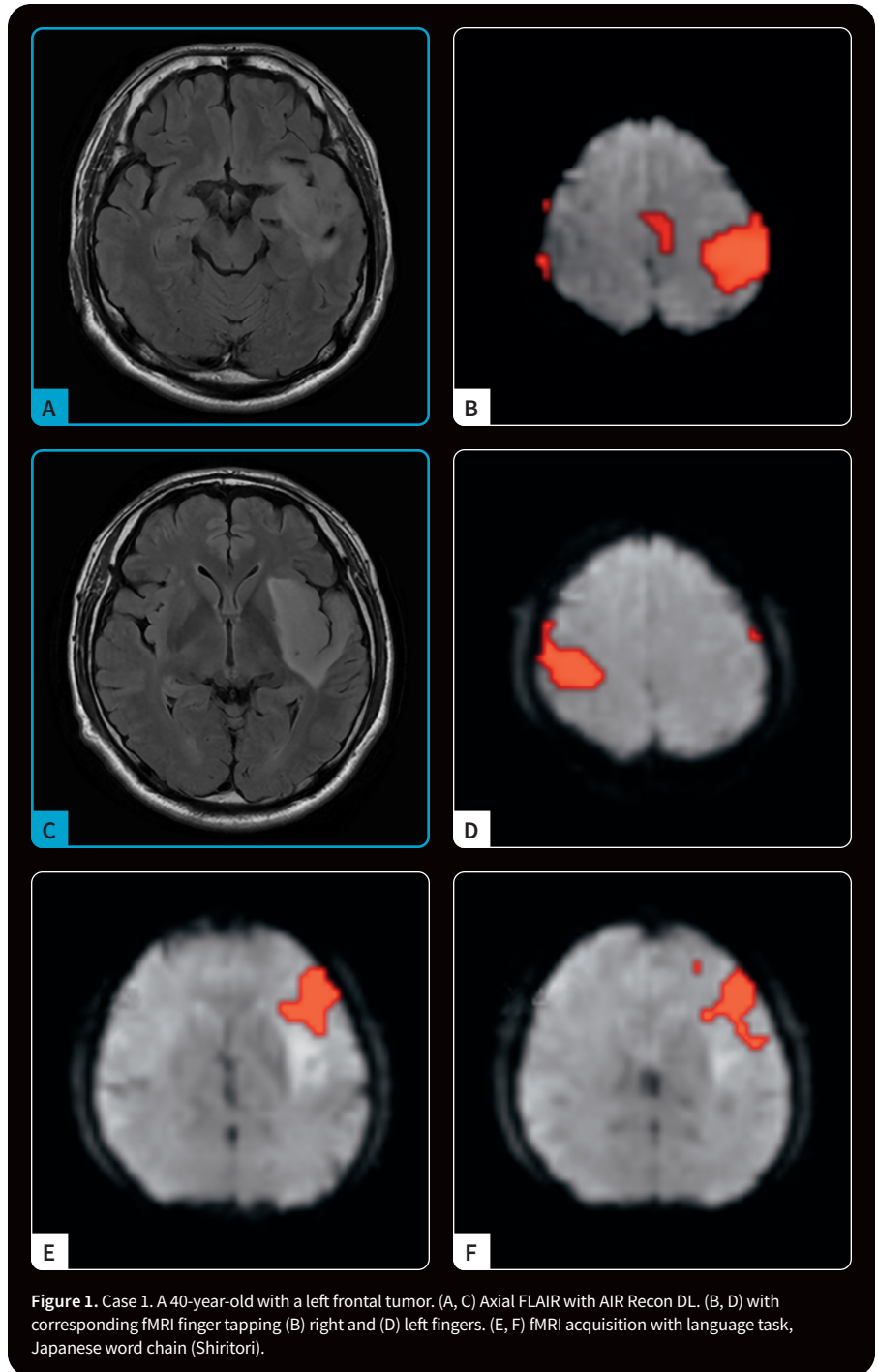
In addition, we acquire DTI data independently of fMRI to visualize the connections between brain regions and plan surgery. This data are also used to depict critical structures like the pyramidal tract, which carries movement-related information from the cerebral cortex to the spinal cord.

fMRI studies performed with SIGNA Architect and BrainWave help our neurosurgeons better prepare for surgery, allowing them to remove lesions to prevent recurrence while preserving essential brain functions. These tools are essential to planning and performing safe surgeries and ensuring better patient outcomes.

## Case 1

### Patient history

A 40-year-old with a left frontal tumor. The patient underwent surgery after an abnormality was found during a detailed examination of his epileptic seizures. fMRI showed that the language area was adjacent to the tumor, so the surgery was performed while the patient was awake. Intraoperative stimulation caused aphasia due to a lesion within the tumor; the area was preserved, and the surgery was completed. The diagnosis was malignant glioma. The surgery was completed without any nerve damage.

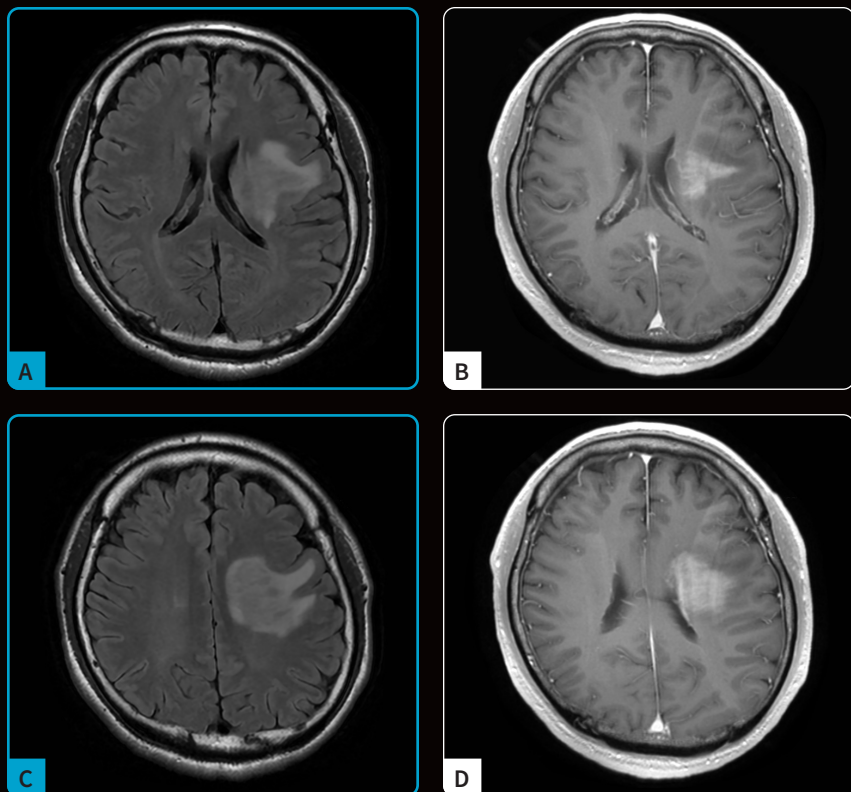


**Figure 1.** Case 1. A 40-year-old with a left frontal tumor. (A, C) Axial FLAIR with AIR Recon DL. (B, D) with corresponding fMRI finger tapping (B) right and (D) left fingers. (E, F) fMRI acquisition with language task, Japanese word chain (Shiritori).

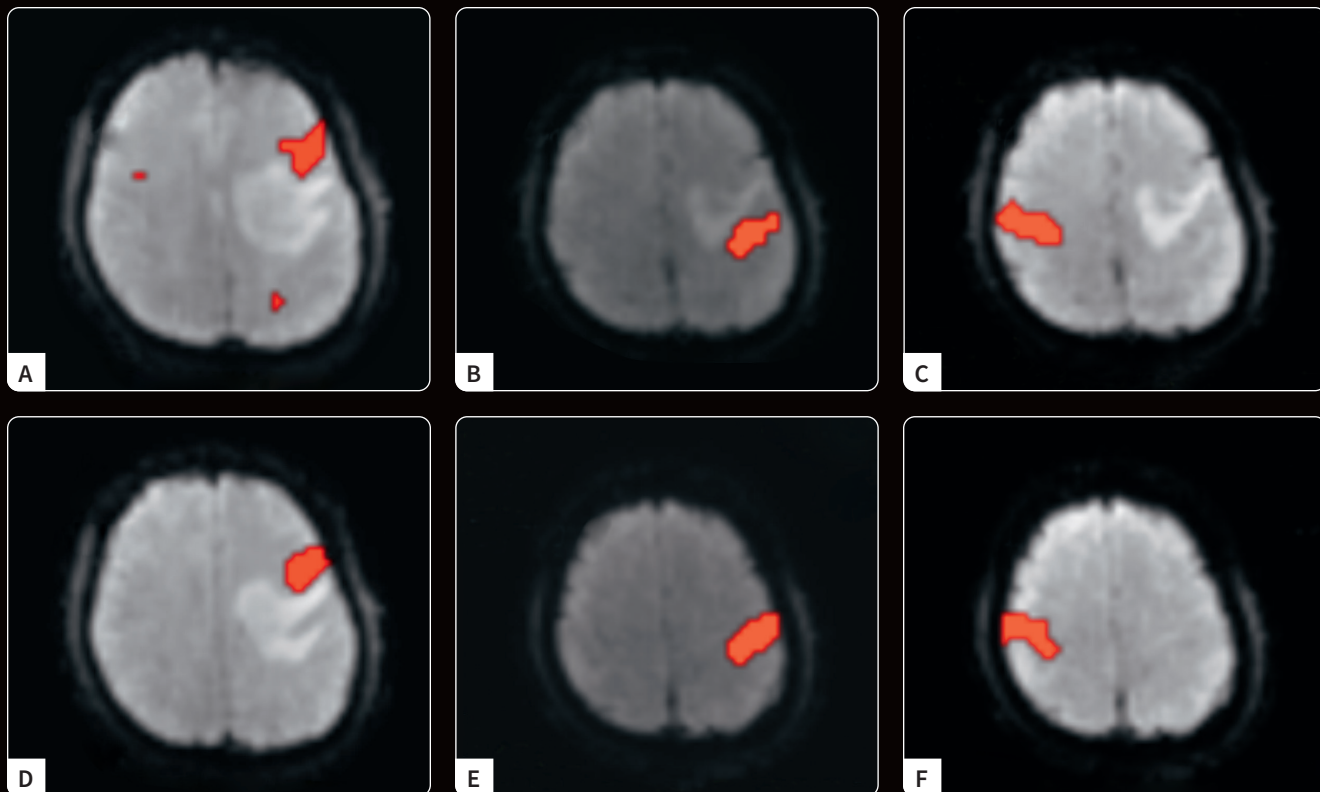
## Case 2

## Patient history

A 54-year-old with demyelinating disease presented with mild difficulty speaking. Detailed examination revealed a brain lesion. An fMRI revealed the lesion was in contact with the language area. There was also the possibility of an inflammatory disease, so an endoscopic biopsy was performed. With the fMRI as a guide, a posterior approach was performed. A transient speech disorder occurred after surgery but improved over time. **S**



**Figure 2.** Case 2. A 54-year-old with demyelinating disease presented with mild difficulty speaking. (A, C) Axial FLAIR with AIR Recon DL and (B, D) axial T1 post-contrast.



**Figure 3.** Corresponding fMRI for case 2, a 54-year-old with demyelinating disease presented with mild difficulty speaking. fMRI helped guide the endoscopic biopsy. (A, D) Language task, Japanese word chain (Shiritori), (B, E) right finger tapping and (C, F) left finger tapping.