Seamless pre-surgical fMRI and DTI mapping

Newest release Achieva 3.0T X-series and Eloquence enable efficient, real-time fMRI for brain activity mapping in clinical practice at Nebraska Medical Center

Clinicians at The Nebraska Medical Center (Omaha, Nebraska, USA) are seamlessly and efficiently performing functional MRI (fMRI) for pre-surgical brain mapping. Improved linking of the center’s Achieva 3.0T X-series scanner and the Eloquence system provides full integration of fMRI and stimulus control. Together with easy analysis of BOLD and DTI data this provides a complete solution for functional and connectivity assessment by MR prior to surgical procedures.

Dr. White uses the Philips FiberTrak Specialist package to track fibers from a DTI dataset. FMRI activation data can be overlaid onto the fiber maps.
The neuroradiology team at The Nebraska Medical Center uses fMRI for pre-surgical planning in the treatment of intracranial tumors. After just three months, the team has embraced the completely integrated workflow provided by the new Philips Elite clinical solution for pre-surgical mapping.

“The streamlined nature of the new setup is incredible,” says Matthew White, M.D., director of Neuroradiology at The Nebraska Medical Center. “It’s very fast and efficient, and we get fMRI exams done within our designated time.”

Since the newest release Achieva 3.0T X-series and Eloquence are fully integrated, the ExamCard not only runs the MR scan but also controls Eloquence’s paradigm generation and automatically starts IViewBold for real-time fMRI analysis.

“The systems now really ‘talk’ to each other,” says Jeremy Van Tilburg, technologist at The Nebraska Medical Center. “We can now build the complete fMRI process into our ExamCards, including synchronization and timing of the paradigm generation protocols of the Eloquence system. So, fMRI becomes a one-step, seamless procedure. And this complete fMRI procedure can be started in one mouse click.”

“We can now build the complete fMRI process into our ExamCards, including synchronization of the paradigm generated by Eloquence.”
Paradigms for activating different functions of the brain

During an fMRI experiment, paradigms created by Eloquence are presented to the patient. Paradigms create stimuli to help activate specific parts of the brain. Activation brings an increase of oxygenated blood. This hemodynamic response – known as Blood Oxygenation Level Dependence, or BOLD – generates changes in the MR signal that can be used to map out the areas of activity.

Paradigms are specific to language, motor, auditory or visual functions of the brain. “If there are concerns about a patient’s language function, we would do word generation paradigms, in which letters are shown to the patient and he or she thinks of a word beginning with that letter,” explains Dr. White. “We could also do verb generation, where the patient is shown a noun and thinks of a verb that relates to that noun. For instance, we could show the word ‘bucket,’ which could generate ‘carry’ or ‘pour.’”

If motor function issues are present, technologists would choose a paradigm such as the moving of left or right fingers, left or right toes, or left or right foot tapping, depending upon where the lesion is.

In patients where auditory function is of concern, passive listening paradigms are given, and word and verb generation also show good activation in both Wernicke’s and Broca’s areas.

For visual stimulation, paradigms usually involve a flashing pattern such as a checkerboard. “What we look for is the triggering of signal changes in the brain,” says Dr. White.

Eloquence offers a large, high-resolution display for the patient, as well as high performance stereo headphones and a button response unit. In the control room, Eloquence has a dedicated computer for uninterrupted stimuli presentation and response collection and a second computer for system control and DICOM images.
“The user interface of the Philips Achieva and its ease of use for selecting a paradigm is exceptional,” says Van Tilburg. “Having that paradigm function during the functional phase of the MRI and having it all in real time so we can watch the paradigm and see if we are getting activation during the stimulation is very useful. The whole paradigm delivery process is very streamlined.”

**Diffusion Tensor Imaging combined with fMRI**

While fMRI can accurately map brain activity, it is limited to gray matter only. Dr. White has been using Diffusion Tensor Imaging (DTI) and fiber tracking, to visualize specific white matter tracts in the brain as well. This is based on measuring the diffusion of water in brain tissue, specifically the directional movement of water molecules. This can help to identify changes in the white matter tracts that may be due to tumors or other anomalies that correlate to cognitive deficits.

When using FiberTrak, the integrated IViewBold package of the Achieva 3.0T X-series allows DTI data to be overlaid onto other images. “We can put in the fMRI sequence and the T1 FLAIR post-gadolinium image, and then do tractography to visualize how the fibers relate to everything else,” explains Van Tilburg. “This is one of the reasons we stuck with Philips.”

**The easy solution for pre-surgical mapping**

The Philips fMRI solution offers easy mapping of functional areas and functional connectivity prior to treatment. This is valuable to clinicians who need integrated, simplified workflow. Because Eloquence is now fully synchronized with the MR scanner, fMRI is as easy as any other MR scan. Real-time processing provided by IViewBold enables monitoring of paradigms, data, and activation maps and allows for interactive parameter manipulation. Data analysis can be performed in real time or in postprocessing. “Without a system like this, you’re just hoping for the best,” says Dr. White. “This system allows the exam to be completed with full confidence that the desired stimulation was obtained.”
Mapping with fMRI sometimes leads to changes in treatment plans

Dr. White says pre-surgical MRI has helped neurosurgeons change their approach. For instance, the neuroradiology team recently saw a 39-year-old female patient who had a lesion in the frontal parietal area. “From other imaging, the surgeon thought it was more of a parietal tumor, but when we did our first anatomical scans, it was obvious that the lesion wasn’t parietal but located on the motor strip on the left,” Dr. White explains. This was confirmed by the fMRI examination, which showed that the right-hand function abutted the lateral aspect of the tumor.” The neurosurgeon had previously planned to do the surgery with the patient asleep so as not to do intra-operative sensory mapping. “But given the location of the lesion and where we saw the activation, the neurosurgeon decided instead to do intra-operative sensory mapping to optimize tumor resection.”

“The DTI tractogram data analysis showed the cortical spinal tract coming up to the inferior aspect of the lesion and then being displaced,” Dr. White continues. “During surgery, when they got to the inferior aspect of resecting the tumor, they were starting to get motor activation, which was in keeping with the tractography findings. The neurosurgeons avoided the tissue lateral to the mass since intra-operative sensory mapping confirmed this area controlled hand function as demonstrated on the fMRI. Post-operative imaging showed that the patient had no residual tumor, and she is now doing very well.”

Another patient came to Dr. White with a low-grade tumor that was growing around Broca’s area on the left. Because Broca’s area controls speech, the patient had been having speech arrest secondary to the tumor, and the team needed to investigate how the language function would map out. “With word generation and verb generation paradigms, the fMRI scan demonstrated activation at the anterior and superior aspects, right adjacent to the tumor,” says Dr. White. “The tractography showed that the arcuate fasciculus extended into the tumor. And the anatomical imaging showed that the lesion was, based on very high resolution images, where Broca’s area would be expected.” Neurosurgeons were able to remove a large central core of the tumor that did not affect the patient’s speech. “After the surgery the patient’s speech was preserved at pre-surgery levels, but no additional language deficit occurred,” says Dr. White.

Information from fMRI exams doesn’t always change the course of treatment, but may enhance it. The neuroradiology team recently performed an fMRI scan on a patient with a recurrent tumor in the temporal occipital region. “We did predominately visual stimulation paradigms, with some language paradigms, which demonstrated that the optic radiations were right above the superior aspect of the tumor,” says Dr. White. It didn’t change the course of treatment, but reassured the neurosurgeon that resecting the tumor would not disrupt the patient’s vision. “There was no room for taking extra margin at the superior aspect, but it gave guidance on the resection as a whole,” he says.