

**TITLE:** Investigations of Structural Brain Abnormalities in Epilepsy with Ultrahigh Field MRI

**PRESENTER/Principal Investigator:** Thomas R. Henry<sup>1</sup>

Co-Investigators: Marie Chupin<sup>2</sup>, Stéphane Lehericy<sup>2,3</sup>, John P. Strupp<sup>4</sup>, Michael A. Sikora<sup>4</sup>, Zhiyi Y. Sha<sup>1</sup>, Kamil Ugurbil<sup>4</sup>, Pierre-Francois Van de Moortele<sup>4</sup>

Affiliations: <sup>1</sup>Neurology, University of Minnesota, Minneapolis, MN, United States, <sup>2</sup>CRICM, Université Pierre et Marie Curie-Paris, UMR S875, Inserm U975, CNRS 7225, Paris, France, <sup>3</sup>Center for NeuroImaging Research – CENIR and Neuroradiology, Pitie-Salpetriere Hospital, Paris, France, <sup>4</sup>Center for Magnetic Resonance Research, University of Minnesota, Minneapolis, Minnesota, United States

Presenter/Principal Investigator: Thomas R. Henry<sup>1</sup>

Co-Investigators: Pierre-Francois Van de Moortele<sup>2</sup>, Marie Chupin<sup>3</sup>, Stéphane Lehericy<sup>3,4</sup>, John P. Strupp<sup>2</sup>, Michael A. Sikora<sup>2</sup>, Zhiyi Y. Sha<sup>1</sup>, Kamil Ugurbil<sup>2</sup>

Affiliations: <sup>1</sup>Neurology, University of Minnesota, Minneapolis, MN, United States, <sup>2</sup>Center for Magnetic Resonance Research, University of Minnesota, Minneapolis, Minnesota, United States, <sup>3</sup>CRICM, Université Pierre et Marie Curie-Paris, UMR S875, Inserm U975, CNRS 7225, Paris, France, <sup>4</sup>Center for NeuroImaging Research – CENIR and Neuroradiology, Pitie-Salpetriere Hospital, Paris, France

**Background:** Clinical 1.5 and 3 Tesla magnetic resonance imaging (MRI) often detects hippocampal sclerosis (HS) in mesial temporal lobe epilepsy (TLE). Focal hippocampal dysplasia associated with HS has been detected histopathologically in TLE surgical specimens. We hypothesized that 7 T MRI might detect hippocampal malformations with HS in TLE, with increased contrast and submillimetric spatial resolution.

**Methods:** We acquired T1- and T2-weighted 7 T brain MRI in 11 healthy subjects and 8 unilateral TLE patients, who consented with IRB approval. Patients had scalp EEG ictal onsets over one temporal lobe, which was ipsilateral to hippocampal atrophy or T2 increases on clinical MRI. T1-weighted, 3-dimensional, magnetization-prepared, rapid acquisition, gradient-recalled-echo (0.8×0.8×0.8mm<sup>3</sup> resolution) sequences imaged the whole brain. T2-weighted, turbo spin echo (0.25×0.25×1.2 mm<sup>3</sup>) sequences imaged the entire hippocampus, in contiguous oblique coronal slices. Data were analyzed qualitatively to define morphology and count hippocampal head digitations. Data were analyzed quantitatively with manual subregional hippocampal body segmentation. Subregional data in individual subjects with TLE were compared with data in control subjects to detect deviation from the control range for volume measures on each side and with asymmetry indexes.

**Results:** All eight patients with TLE had hippocampal abnormalities on the epileptogenic side. Subregional analysis revealed selective lateral Ammon horn atrophy in six patients and diffuse Ammon horn and dentate gyrus atrophy in one patient. Paucity of hippocampal digitations occurred on the epileptogenic side in all patients with TLE and also on the contralateral side in three patients (interrater k value, 0.80). Hippocampal malrotation was observed in three patients with TLE and four control subjects.

**Conclusions:** Ultrahigh field MRI generated high contrast-high spatial resolution images which defined internal and external hippocampal morphology more clearly than did clinical MRI. Hypoplasia of the hippocampal head may be highly associated with HS, but can occur contralateral to HS in TLE patients. Absence or paucity of digitations of the hippocampal head may represent a specific deformity of hippocampal morphology in mesial TLE. Histopathological correlation will be required to determine whether this deformity is an MRI sign of hippocampal dysplasia. Malrotation of the hippocampal body may be a normal variant of hippocampal morphology.

**Future Directions:** Improved contrast and submillimetric spatial resolution at 7 T should considerably enhance future pathophysiological research and perhaps surgical planning in TLE. This improved resolution also should assist in detecting subtle malformations of cortical development and other lesions in “MRI negative” epilepsies, and in better characterizing lesions detected at lower field. Smaller stereotactic targets for intracranial EEG monitoring and deep brain stimulation may be more accurately localized with 7 T MRI in the future. The ability to safely perform higher resolution brain MRI at intervals over the years should help to better understand the development and consequences of various epilepsies. Non-structural analyses of ultrahigh field MRI may also be considerably enhanced, particularly including functional MRI and MR spectroscopy, in the epilepsies.

**Acknowledgments:** Supported by NIH P41 RR008079 & P30 NS057091, and the Keck Foundation.

**Publication:** Additional information on this study is available in:  
*Radiology* 261: 199-209, 2011.