

Ammon's Horn Sclerosis Detected in Temporal Lobe Epilepsy with 7 T MRI

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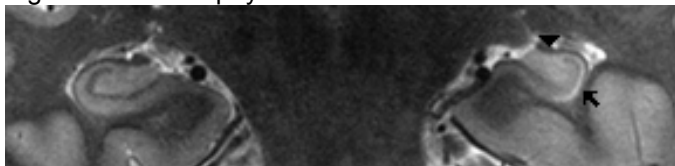
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Background: Hippocampal atrophy is detectable with clinical MRI in conditions that are associated with neuronal loss in the hippocampal formation. Ammon's horn sclerosis (loss of pyramidal neurons predominantly in the CA1 region, with sprouting of mossy fibers of dentate granule cells, and often with lesser CA3 and dentate hilar neuronal loss) is highly associated with limbic temporal lobe epilepsy (TLE). End-folium sclerosis (neuronal loss in CA4 and the adjacent hilus of the dentate gyrus) is observed after convulsive status epilepticus in various epilepsies. Ammon's horn sclerosis and end-folium sclerosis co-exist in severe TLE. In patients with hippocampal sclerosis, intrahippocampal gray-white matter contrast on 3 T MRI studies may be insufficient to demonstrate the continuous band of intrahippocampal white matter on the banks of the hippocampal sulcus, although this white matter band is continuous on microscopy of sclerotic hippocampal specimens. This observation has been termed the "partial loss of hippocampal striation", and is considered a sign of hippocampal sclerosis (1). We acquired 7 T MRI in TLE patients who had hippocampal atrophy on 3 T MRI studies, to determine whether subregional hippocampal anatomy is reliably detectable at 7 T.

Methods: We recruited 10 healthy adult volunteers and 5 adult TLE patients for MR imaging at 7 T in this IRB-approved study. Each adult patient was diagnosed with limbic TLE based on ictal video-EEG recordings and other data. For each TLE patient, MR images acquired at 3 T showed unilateral hippocampal atrophy ipsilateral to EEG ictal onsets. In each case the 3 T data showed partial interruption of the major band of intrahippocampal white matter ("hippocampal striation"). The 5 patients and 10 healthy volunteers were imaged at 7 T (Siemens, Erlangen, Germany) using a 16-channel head coil. The protocol lasted about 40 minutes and included scout images for positioning followed by B0 shimming, whole brain T1w 3D MPRAGE (0.8x0.8x0.8 mm³ resolution, TR/TE = 15ms/5.74ms, GRAPPA R=2, $\alpha=4^\circ$) images, and multislice T2w Turbo Spin Echo (TSE) coronal oblique views (TR/TE = 4000ms/77ms, Nex = 1, matrix size 512x512). The orientation for T2w-TSE was set perpendicular to the long hippocampal axis, and 54 contiguous slices of 1.0 mm, without gap, were acquired with 0.25x0.25mm² in plane resolution. In order to not exceed SAR limits, only 27 slices were acquired at a time and the HyperEcho option was used in TSE with $\alpha=60^\circ$. Each slab of 27 slices was collected 2 or 3 times for averaging. All T1w and T2w images were qualitatively scored by two neuroradiologists independently. We manually segmented the CA1-3 subregion and the CA4-dentate subregion of the hippocampal bodies bilaterally on the T2w coronal images as previously described (2). Subregional volumes were compared as asymmetry indices.

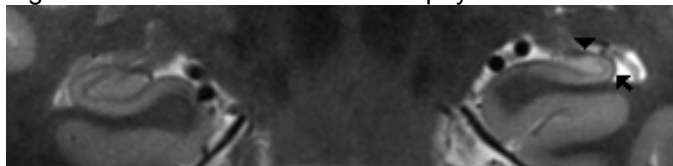
Results: In each subject the hippocampal striation and additional detailed anatomical features were clearly apparent on the T2w images obtained at 7 T. Two important qualitative observations were made. 1) In each set it was possible to delineate a continuous hippocampal striation, although this white matter band tended to be less distinct from surrounding gray matter in atrophic hippocampi. 2) Each atrophic hippocampus had a decreased thickness of the CA1-3 subregion, but only in a single case was the latter associated with a smaller CA4-dentate size. In agreement with these qualitative observations, volumetric asymmetry of the hippocampal CA1-3 subregions was observed in 4 TLE patients, in the absence of CA4-dentate asymmetry, as exemplified in Fig 1. The fifth TLE patient had significant asymmetry both of CA1-3 and CA4-dentate, compared with control values, as shown in Fig. 2.

Fig. 1: CA1-3 atrophy



CA1-3 at arrow.

Fig. 2: CA4-dentate and CA1-3 atrophy



CA4-dentate at arrowhead.

Conclusions: Increased contrast and spatial resolution at 7 T permitted the reliable detection of internal architecture of the hippocampal formation. Submillimetric T2w images at 7 T consistently resolved the continuous white matter band, which separates deep portions of CA1-3 from CA4 and the dentate hilus. The resulting accuracy permitted intrahippocampal (subregional) volumetry. These preliminary results strongly support expectations that brain imaging at very high magnetic field may allow for a more accurate patient classification based on qualitative and quantitative information that is difficult or impossible to collect reliably at lower field.

References: (1) Hanamiya M, et al. *Radiology* 251:873-81, 2009. (2) Chupin M, et al. *ISMRM* p.49, 2009.

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