High Resolution MRI of Brainstem at 8 Tesla

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Introduction
The brainstem represents a small but vital part of the brain. It is a railway station of dominant cerebral pathways; it integrates structures controlling consciousness, respiration, cardiovascular and visceral functions and it is necessary for survival. Even small lesions in this area could be life-threatening. Thus, it is highly desirable to have ability to image brainstem at high resolution. Due to small brainstem size, high structural complexity and deep subcortical location, standard MRI at 1.5 Tesla provide only coarse resolution of brainstem anatomy. The goal of this study was to evaluate potential of the high field MRI (8 Tesla) of brainstem in normal subjects.

Methods
The images were acquired with 8T/80cm whole body MR systems using a dedicated head gradient. A Bruker AVANCE (Billerica, MA) console was used for image acquisition. A quadrature driven Transverse Electromagnetic (TEM) resonator was tuned on each subject. An RF limiting switch was inserted in the transmit line to ensure less than FDA RF exposure level. A high degree of homogeneity was achieved on all subjects. A Q value of 25-30 was obtained for the subjects of this study. Particular care was paid to the extent of the subject head insertion into the coil to guarantee brain stem as well as the whole brain images. The acquisition parameters for the images shown were: TR=1000 msec, TE=7 msec, FOV=20 cm, matrix 512 x 512, number of slices = 16, receiver bandwidth=72 kHz, slice thickness= 2 mm, GRE. A 4 msec gaussian was used to accomplish spin excitations.

Results
High resolution images of the brainstem enables the delineation of certain brainstem structures. In general, it is possible to distinguish between predominantly myelinated tracts comprising mainly anterior portion of the brainstem and nuclear complexes or less myelinated structures located more posteriorly. Oculomotor complex corresponds to higher density (increased signal) in T2 images in upper posterior midbrain and fibers originating here could be followed towards ventral part where they exit. Crossed fibers of the superior cerebral peduncle were seen mainly in lower midbrain. In the pons, lower density areas (decreased signal) in its ventral portion correspond to cortico-pontine tract with interspaced pontine nuclei. The pyramidal tract (lower density on T2) located dorsally is relatively well separated from trapezoid body. In upper medulla, there is a high density area corresponding to the inferior olive with less demarcated pattern of gray matter. Regarding the cerebellum, remarkable details of gyri folding pattern with good separation between gray and white matter was seen. In addition, numerous small veins penetrating cerebellum and brainstem were recognized having similar (increased signal) density as gray matter Large-caliber vessels such as vein of Galen, superior vein or anterior pontomesencephalic vein were recognized as well.

Discussion
Ultra high field MRI (8 T) provides improved resolution of the brainstem and other posterior fossa structures. The contrast between gray and white matter is lower in brainstem compared to cortex however it follows known anatomical landmarks. Thus high field MRI may substantially improve diagnostic yield of posterior fossa imaging.

Figure 1. Sagittal 8 Tesla T2 image of a healthy volunteer.

Figure 2. Portion of the MRI scan of another healthy subject showing posterior fossa structures - midbrain, portion of pons and cerebellum.