3D visualization of deep cerebellar nuclei using 7T MRI

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Introduction

There are various ways to study the function of the human cerebellum. One method, which has long been used, is to examine the impairments in human subjects with cerebellar lesions. In order to perform lesion-symptom mapping within the cerebellum, good knowledge about the cerebellar lesion site is required. Structural magnetic resonance imaging (MRI) is helpful to determine the localization and extent of cerebellar lesions. The affected cerebellar lobules can be defined with good precision both in subjects with degenerative and focal cerebellar lesions. Techniques to visualize the deep cerebellar nuclei and to identify possible lesions, however, are less advanced.

In the cerebellar nuclei of human subjects, the amount of iron is high compared to the rest of the brain. Clusters of iron are paramagnetic and therefore tend to cause local inhomogeneities in a magnetic field. The iron-induced susceptibility artifacts can be used to visualize the cerebellar nuclei as hypointensities on MR images [1, 2].

It is well known that susceptibility artifacts and signal-to-noise ratio increase with increasing field strength. The aim of the present study was to use ultra-high field MRI (7T) to visualize the deep cerebellar nuclei in the submillimeter range in healthy subjects.

Methods

Sixteen neurologically healthy control subjects participated (six male, ten female; mean age 26.7 SD 5.7 years, 21-46 years). T2*-weighted susceptibility weighted imaging (SWI, TR/TE = 35/16.9 ms , FOV 224 x 182 mm^2, flip 19°, BW 160 Hz/pixel, 144 slices, matrix 448 x 364, slice thickness 0.5 mm, voxel size was 0.5x0.5x0.5 mm^3, Grappa R = 2, TA 16:14 min) was performed with a whole-body 7T MR scanner (Magnetom 7T, Siemens Healthcare, Erlangen, Germany) and an eight-channel transmit/receive head coil (Rapid Biomed, Wuerzburg, Germany). Deep cerebellar nuclei (dentate, emboliform, globose, and fastigial nuclei) were visually identified on phase and SWI images. Cerebellar nuclei were identified on each of the 0.5 mm MR sections in the transverse, coronal, and sagittal planes by comparison with available atlases of the cerebellum. Individual nuclei were marked as regions of interest (ROIs) using MRICro software (http://www.sph.sc.edu/comd/rorden/mricro.html). ROIs were visualized in 3D space using Eccet software (http://eccet.acs.uni-duesseldorf.de/).

Results

Dentate nuclei could be identified in all of the subjects. Globose nuclei were identified in 15 of the 16 subjects, emboliform nuclei in 13 subjects, and fastigial nuclei in 10 subjects. Nuclei are shown as hypointensities (Fig. 1 A) and as color drawings (Fig. 1 B) in coronal SWI images of a representative subject. A 3D view of the same nuclei is given in (Fig. 1 C). The dentate nuclei (blue) have the characteristic shape of a crumpled purse, with the hilus directed ventromedially and rostrally. The globose nucleus (purple) is located more medially, the emboliform (green) more laterally. The globose and emboliform nuclei have about the same rostrocaudal extent. The fastigial nuclei are located next to the midline (red).

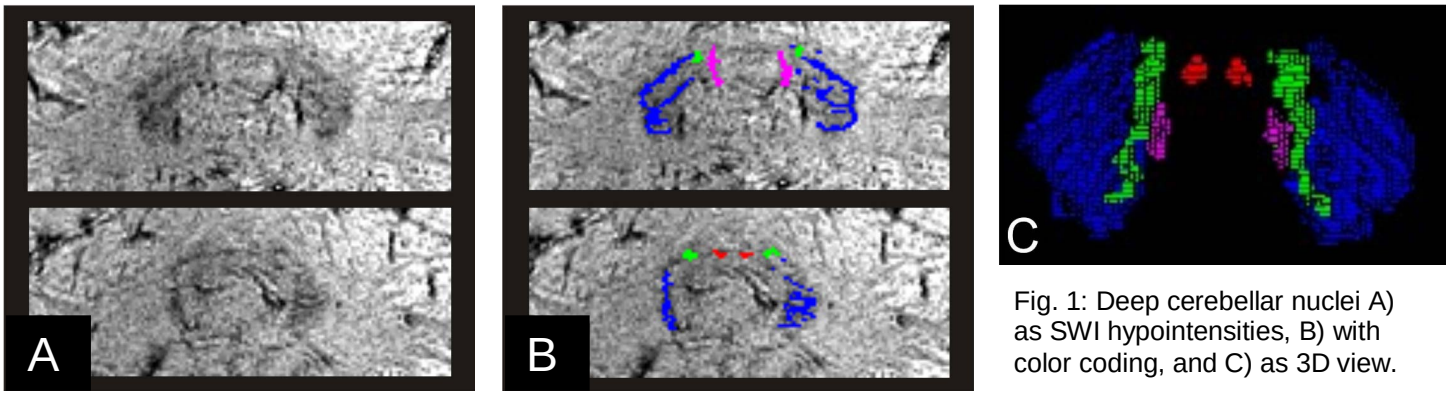

Fig. 1: Deep cerebellar nuclei A) as SWI hypointensities, B) with color coding, and C) as 3D view.

Conclusions

Ultra-high field 7T MRI is helpful to visualize the deep cerebellar nuclei in healthy human subjects on an individual level. The dentate nucleus can be seen with great precision. Moreover, the smaller cerebellar nuclei (emboliform, globose, and fastigial nuclei) can be visualized and separated from each other in a high percentage of healthy subjects. Use of this technique is envisaged to be helpful in identifying lesions of the nuclei in subjects with focal cerebellar lesions. Differential identification of the nuclei is important to get information about the lateral (dentate nucleus), intermediate (emboliform and globose nuclei) and medial (fastigial nuclei) zone in human cerebellar lesion studies. In an ongoing study, structural imaging of the nuclei is being investigated with further improved spatial resolution (0.3 mm^3 isotropic voxel size).

References

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