Detection of the Stria of Gennari using Turbo Spin Echo Imaging at High Field

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Introduction

The striate cortex in the calcarine sulcus can be distinguished from neighbouring regions by the presence of the stria of Gennari, a dense band of myelination within the cortical grey matter. MRI sequences providing contrast between grey and white matter potentially allow detection of the stria, but this is only possible with very high resolution imaging, since the thickness of the myelin band is of the order of 0.3 mm (1). In previous work, detection of the stria has generally been accomplished by using fast, three dimensional spoiled gradient echo sequences with a partial inversion prior to acquisition of each plane of k-space so as to yield optimal contrast between grey and white matter (1-4). Here, we show that multi-slice, turbo spin echo (TSE) imaging (5), used in conjunction with inversion recovery at 3 T and 7T provides an alternative method for the identification of the stria of Gennari in a reasonable measurement time.

Methods

Imaging was performed on 3 and 7 T Philips Achieva scanners. Four subjects were scanned at each field strength using a TSE sequence to acquire slices with an in-plane resolution of 0.35 x 0.35 mm^2 and 1.5 mm thickness (FOV=180mm x 180mm; matrix size = 512 x 512) . It was found that the optimal contrast between grey and white matter was obtained by preceding the TSE acquisition with an inversion recovery to produce mixed T_1 and T_2 contrast.

7T: TSE images were acquired using a volume T/R coil. Optimal contrast was found for an inversion recovery time of 320 ms and an echo time of 10 ms, with a repetition time of 3200 ms and a TSE shot duration of 150 ms. The echo train length (ETL) was 15, the refocusing angle 160^o, and centric phase encoding order was used. Image data sets comprising 4 slices in the occipital lobe aligned perpendicular to the plane of the calcarine sulcus were acquired .6 averages were performed in total, by acquiring 3 individual data sets each formed from two averages. Each of these data sets was acquired in 7.5 minutes, leading to a total scan time of 22.5 minutes.

3T: At 3T, an 8-channel SENSE head coil was used. In a single scanning session, images were acquired in three orientations so as to provide full coverage of the visual cortex. The three image data sets consisted of 15 slices in midline sagittal orientation,15 slices aligned perpendicular and 10 slices aligned parallel to the plane of the calcarine sulcus, each acquired using a SENSE factor of 2.5 (RL). For these experiments, the inversion recovery, repetition and echo time were 220ms, 3200 ms, and 70 ms respectively, the ETL was 19 and refocusing angle 140^0, and linear phase encoding order was used. For each orientation a total number of 12 averages were performed, grouped into 6 individual data sets of 2 averages acquired in 211 s (153s for sagittal), leading to a total scan time of 57min30sec. Motion correction was applied before averaging together each of the individual data sets.

In two further subjects, the extent of primary visual cortex (V1) (which corresponds to Brodmann's area 17) was determined from previously acquired retinotopic mapping data (4) and after co-registartion this information was overlaid onto the TSE images. These maps were based on EPI images of resolution 2x2x2 mm^3, covering the visual cortex, which were acquired at 3 T.

Results and Discussion

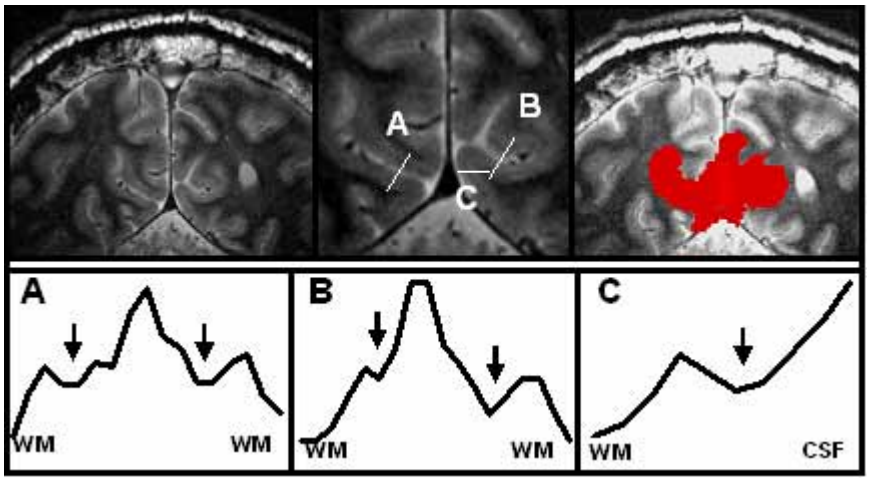

Figure 1: (i) High resolution images (0.35x 0.35 x 1.5 mm^3) from the 7T scanner showing a hypointense band (stria of Gennari) within the grey matter (ii) Magnified region from (i) showing position of line profiles (iii) V1 map overlaid onto IR-TSE (A,B,C) line profiles through sulci along the lines marked on image (ii).

	GM/WM	GM/Stria
3T	4.8	1.4
7T	9.2	4.0

Table 1: Mean ratio of the contrast between grey and white matter to noise and grey and stria of Gennari to noise for both field strengths.

A hypointense band within the cortical grey matter indicating the stria of Gennari was visible in the visual cortex in slices aligned perpendicular to the calcarine sulcus for all four subjects at both field strengths. The additional slice orientations and brain coverage taken at 3T allowed visualization of the stria in the visual cortex as well as laminar grey matter structures in other regions of the brain, including the pre/-post central sulcus and parietal sulcus.

Figure 1(i) shows IR-TSE data acquired from one subject at 7T. The highest signal intensity occurs in CSF, with grey matter appearing with significantly higher intensity than white matter. The image on the left shows a magnification of the region where the stria was visible; a dark band can clearly be seen within parts of the grey matter along the calcarine sulcus. Intensity profiles were measured across the sulci at different locations where the stria was most evident. Profiles A and B were measured from the edge of the white matter across the CSF to the edge of the white matter and C from the edge of white matter (WM) to the edge of the CSF (from left to right). A dip in signal intensity, shown by the arrow, is present in all examples, indicating the presence of a band of myelination.

Table 1 details the contrast to noise ratio (CNR) between grey and white matter and grey matter and the myelinated band, measured in those slices aligned perpendicular to the calcarine sulcus. It can be seen that the CNR is significantly greater at 7 than 3T.

Figure 1 (iii) shows the extent of V1 determined from the retinotopic mapping data overlaid on the IR-TSE. Regions showing the hypointense band can be seen to be confined to

Conclusion

We have shown that IR-TSE sequence can be used at 3T and 7T to identify the dense band of myelination in the striate cortex in reasonable measurement times. A hypointense band of signal intensity in grey matter of the occipital lobe was seen in all four subjects scanned. The improved contrast to noise ratio between grey matter and the myelination band at 7T allows a better localization of the stria of Gennari , which has been shown to correspond to define the extent of V1.

References

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