

Optic Nerve Characterisation by Isotropic High-Resolution MRI

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Introduction

Many ophthalmological and neurological pathologies affect the optic nerve which provides the brain with retinal information. Revealing their characteristic manifestations with isotropic, high-resolution imaging of the optic nerve, the orbit and the chiasm may allow early and direct diagnosis of diseases that result in loss of visual function, partial or complete blindness [1,2]. In this pilot study, we present isotropic, high-resolution optic nerve images which may be suitable for clinical applications.

Methods

All measurements were performed on a 3T scanner (Siemens Tim-Trio), equipped with a 40mT/m gradient coil. A 12 channel phased-array RF coil was used for reception and a body coil was used for excitation. One informed patient (male, 71 years old) with a vascular lesion in the territory of the left posterior cerebral artery was studied. For the high-resolution investigation of the orbit, the optic nerve, and the chiasm a 3D magnetisation-prepared turbo spin echo sequence (TSE) was used. The TSE measurement parameters were: TR=2860 ms; TE=17ms; TI=250ms; flip angle=180; turbo factor=23; FOV=175x175x0.5 mm; matrix size 384x384. A 24-slice volume was carefully positioned to capture the retino-thalamic axis on the basis of a high-resolution MP-RAGE scan (Fig. 1A and below for details). The inversion time TI was carefully chosen in order to null the signal coming from tissue directly adjacent to the optic nerve to maximise contrast.

To further improve image quality, two identical data sets were acquired in succession. The highest close-to-isotropic resolution

(0.45x0.45x0.5mm) was chosen such that the SNR in each set still allowed for good coregistration. An acceleration factor of 2 maintained the total acquisition time per scan at ~ 10 mins. The repetition time, inversion time and turbo factor were optimised for signal, contrast and resolution (PSF properties)[3]. The two measurements were combined using a Fourier-Mellin [4] transform to correct for in plane motion between the scans and to produce high-resolution and high SNR images. As already stated, 3D images of the whole brain were acquired with the MP-RAGE sequence optimized for high isotropic (0.875 x 0.875 x 0.875 mm) resolution with the following acquisition parameters: TR=2250 ms; TE=3.1ms; TI=966ms; flip angle = 9°.

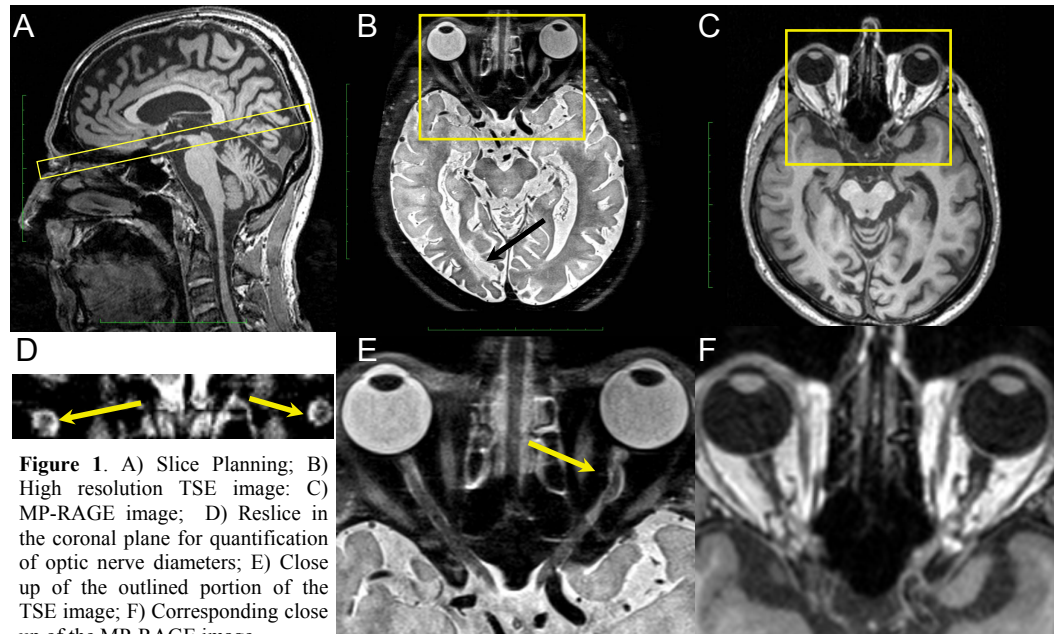


Figure 1. A) Slice Planning; B) High resolution TSE image; C) MP-RAGE image; D) Reslice in the coronal plane for quantification of optic nerve diameters; E) Close up of the outlined portion of the TSE image; F) Corresponding close up of the MP-RAGE image.

Results

Figure 1B shows an image from the high-resolution TSE sequence. The image shows high T2-weighted contrast with high SNR and reveals the anatomy of both optic nerves. The image also shows the left optic radiation lesion (see arrow). A close-up of the region outlined in Figure 1A is shown in Figure 1E. Here, an abnormal curvature in the right optic nerve is clearly visible.

Corresponding views of the high-resolution transverse MP-RAGE image are shown in Figures 1C and F. The typical T1-weighted signal together with the lower resolution of these images does not allow for a clear delineation of the optic nerves, impairing a full characterisation of structural abnormalities.

Discussion

Our study demonstrates that careful optimization of the TSE sequence significantly increases the resolution for *in vivo* optic nerve imaging. With the close-to-isotropic voxels of the 3D slab, the dimensions of the nerves can be quantified in any direction by reslicing the 3D dataset in any given plane, as shown in Figure 1D for a coronal view. We expect the method to complement and extend others, e.g. fundoscopic optic nerve head imaging, in clinical applications and research.

References

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