

Contrast simulation and measurement in the optic nerve at 3T

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INTRODUCTION

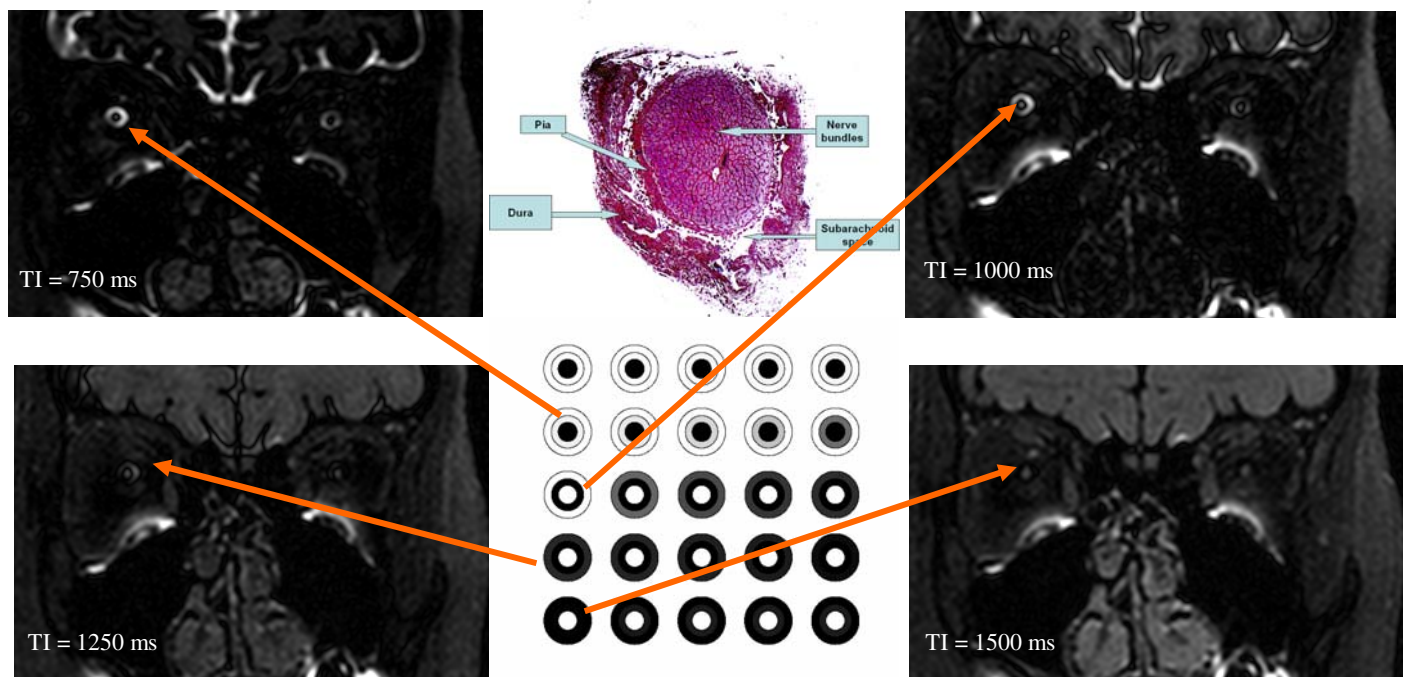
Measurement of optic nerve diameter has been widely used in studies of optic neuritis associated with Multiple Sclerosis. Many of these studies assume that the optic nerve measures 2.5-3.5mm diameter and is surrounded by a thin sheath which includes a CSF space of 1-2mm annular thickness. For this reason, many studies use sequences designed to eliminate signal from the CSF so that the optic nerve can be measured accurately (1). However, inspection of high resolution anatomical images and reports from pathologists on the optic nerve show that the CSF space is actually very thin in the optic nerve and unlikely to be the major component providing tissue contrast due to a large partial volume effect with the surrounding arachnoid and dural tissues. We have set up a contrast simulation of the optic nerve including more realistic tissue dimensions and assumed values for Proton Density (PD), T1, and T2 relaxation times estimated from the contrast behaviour of the acquired images for each of the three compartments. We have compared the contrast simulation with isotropic high resolution T1 and T2 weighted 3D gradient echo sequences and a 2D thin slice IR FSE sequence with four different inversion times in 5 volunteers.

METHODS

Equations for the signal dependence on PD and the relaxation times were programmed in Matlab for a simulated cross section of the optic nerve and a range of imaging sequences (1). In a 64x64 image matrix, the sheath outer diameter was 5mm, the arachnoid, pial and CSF diameter was 3.4mm and the optic nerve 2mm with a single PD, T1 and T2 value associated with each compartment. Images were acquired at 3T using an 8 channel SENSE head coil (Achieva, Philips, Best, NL) using a 3D T2 weighted SPIR sequence with isotropic 0.75mm resolution, TR/TE = 2000/140ms, NEX=1 with a FA = 90°, a 3D T1 weighted (same parameters except FA = 35°) and a 2D FLAIR sequence with TR/TE = 4000/120ms, voxel size = 1.0 x 1.0 x 1.5 mm³ and four different inversion times, TI = 750,100,1250 and 1500ms.

RESULTS

The anatomical image (top centre) is a cross section of the optic nerve showing the three main compartments. The lower centre figure shows a simulation of optic nerve contrast as a function of TI for an IR sequence with TI = 500-1700ms in 50ms steps with TR/TE = 4000/120ms and with PD=100 and T2 =100ms for each compartment. Three different contrast regions are expected as TI varies yielding 'hole' and 'target' appearances. Arrows compare simulations with measurements. The greyscale images below shows coronal images acquired with the 2D sequence at 3T with TI =750ms (top left), 1000ms (top right), 1250 ms (lower left) and 1500ms (lower right) respectively. The estimated T1's for the dura, pia and the optic nerve bundle were 3000, 2500 and 1000ms respectively.



DISCUSSION

It can be seen from the simulations and the acquired images that the optic nerve contrast is a complicated function of TI. An appropriate choice of TI is required to suppress the mixed signals for determining the optic nerve bundle thickness in cases of optic neuritis. A TI of 1500ms seems appropriate to image the nerve bundle at 3T whereas 1042ms was used at 1.5T (1). It is actually the dural, pial and arachnoid tissues which need to be suppressed while the CSF is only a very small fraction of the overall volume.

REFERENCES 1. Hickman SJ et al., *Neuroradiology* 2001;43:123-128.