High Resolution MRI at 3T demonstrates significant change in diameter of the optic nerve during 30° abduction

M. Weigel[1], T. Bley[1], W. A. Lagrèze[2], A. Lazzaro[2], J. Hennig[1]

[1]Department of Radiology, Medical Physics, University Hospital Freiburg, Freiburg, Germany, [2]Department of Opthalmology, University Hospital Freiburg, Freiburg, Germany

Introduction

The optic nerve (ON) is surrounded by cerebrospinal fluid (CSF) and the dura mater [1]. With increasing age [2] and under certain pathologic conditions (e.g. intracranial hypertension) its diameter changes. As an alternative to ultrasonography [1, 2] we present a novel MRI approach to noninvasively image the ON sheath *in vivo* and to quantify its diameter. This contribution shows that the new technique can be employed to assess changes in the ON's diameter between straight view and 30° abduction.

Materials and Methods

The ON of 20 healthy volunteers (age 22-39, mean 25) without any history of eye diseases was investigated. High resolution MRI was performed on a 3T scanner (Siemens Trio, Erlangen, Germany) using an eight channel phased-array head coil. A fast T2 weighted axial and sagittal TSE sequence were used for planning: TR/TE = 4000/123ms, spatial resolution = 0.41x0.47mm^2, slth = 5mm, 7 slices, ETL=25, Half Fourier reconstruction, TA = 1:06min. The ON diameter was quantified via a modified Half Fourier Single Shot Multi Spin Echo (HASTE) sequence acquired perpendicular to the optic nerve orientation: TR/TE = 5000/146ms, spatial resolution = 0.45×0.50mm^2, slth = 3mm, TA = 15sec, short rf pulses. Three slices were positioned: 1) directly retrobulbar (anterior), 2) in the mid, and 3) in the distal part of the intraorbital track of the optic nerve (posterior). Both, localizer TSE and HASTE sequences were acquired twice with the volunteer looking straight ahead and in 30° side gaze. Measurements of the ON's diameter were performed using a state-of-the-art radiology work station (J-Vision, TIANI, Vienna, Austria). The whole protocol lasted less than 6min.

Results

Figure 1 displays images from one of the volunteers looking straight ahead (0°). **(a)** and **(b)** in the top row represent the fast localizer TSE images used for planning. Both resolve the optic nerve well and present a valuable contrast between the ON system and its surrounding fat. In the bottom row the corresponding HASTE images for quantitation are shown: **(c)** anterior / retrobulbar, **(d)** middle, **(e)** posterior. Even in the distal part the liqour ring could be depicted clearly as well as the optic muscles. Note the diminution of the liquor sheath from anterior to posterior.

In **Table 1** the assessed diameters of the ON are shown. Its diameter ranges from 3.22mm (anterior) to 2.70mm (posterior). During abduction (30°) the ON diameter decreases to 3.05mm (anterior) and 2.55mm (posterior). This change was found to be highly significant anterior / directly retrobulbar ($p<0.001$) and significant in the middle and posterior location ($p<0.05$). Thus, the presented MRI technique could verify the expected thinning of the ON during abduction caused by its necessary extension.

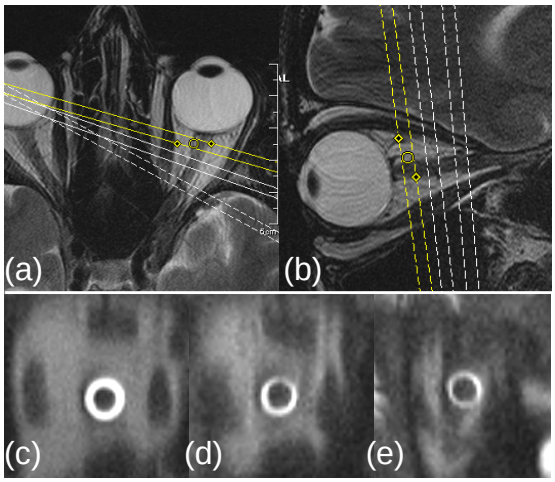

Figure 1: (a) and **(b)**: Localizer-TSE images, the positioning of slices is shown.
(c) – **(e)**: HASTE images for quantitation (anterior, middle, posterior). Note the diminution of the liquor sheath.

Discussion

It could be shown that High Resolution MRI at 3T is well capable of resolving the optic nerve system with its liquor sheath. The presented technique allows to quantify the ON diameter and to assess its changes between straight view and 30° lateral view. The liquor sheath consists of CSF with long T1 and T2 decay. Thus, the HASTE sequence with short rf pulses proved to be excellent for this task. A single shot sequence does not exhibit any T1 weighting and the long T2 decay allows to use long echo trains without any sacrifice in contrast or resolution. The applied sequences represent a trade-off between high resolution and a clinically valuable contrast to noise ratio. Signal averaging was avoided since it demonstrated to produce artifacts by slight movement of the eye between the measurements. We conclude that High Resolution MRI at 3T can quantify changes in the ON diameter, e.g. during eye movement. The presented technique of resolving the optic nerve and its quantitation of diameter is highly valuable for clinical MRI. It can be applied to patients with intracranial hypertension and for assessment of differential diagnoses in optic nerve disease. Additionally, it is less observer dependent than ultrasonography. Further studies are in progress.

position	anterior		middle		posterior	
eye direction	0°	30°	0°	30°	0°	30°
mean ON ∅ / mm	3.22	3.05	2.90	2.80	2.70	2.55
SE (ON ∅ / mm)	0.06	0.06	0.07	0.06	0.07	0.07
T-Test	p < 0.001		p < 0.05		p < 0.05	

Table 1: Overview of assessed ON diameters at all 3 locations watching straight and by 30° to the side. Significant decreases can be observed.

References

1.) Helmke K, Hansen HC. Pediat. Radiol 1996, 26:701-705
2.) Beatty S, Good PA, McLaughlin J, O`Neill EC. British Joural of Opthalmology 1998,82:43-47