Quantification of glaucomatous optic atrophy utilizing high resolution MRI of the optic nerve

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Introduction: The optic nerve (ON) is surrounded by subarachnoidal cerebrospinal fluid (CSF) and dura mater. With age and under certain pathologic conditions, such as glaucoma the diameter of the ON and its CSF sheath may change [1, 2]. Non-invasive diagnosis of the ON sheath by means of ultrasonography has been described. However, it is known to depend on personal experience and to be subjected to inter-observer and test–retest variability [3]. The aim of this study was to evaluate the diameter of the retro-bulbar optic nerve as a surrogate marker for axonal atrophy in glaucoma utilizing high resolution MRI of the optic nerve.

Methods: 47 glaucoma patients (mean age 64 years) and nine healthy subjects (mean age 54 years) were scheduled for 3 Tesla MRI (Trio, Siemens Medical Systems, Erlangen, Germany). HASTE sequences were acquired in straight gaze perpendicular to the optic nerve within 5 mm, 10 mm and 15 mm behind the eye (TR/TE 1500/146 ms, TA 1.5 sec., number of excitations 1, bandwidth 195 Hz/pixel, FOV 23 x 18 cm2, Matrix 512 x 367, nominal spatial resolution 0.45 x 0.49 mm^2, interpolated to a higher matrix size of 2048 x 1468 with a pixel size of 0.11 x 0.12 mm^2, slice thickness 3 mm) as reported previously [4]. Measurements of the ON were correlated with the degree of glaucoma.

Results: HASTE-sequences yielded high contrast between cerebrospinal fluid and optic nerve parenchyma. Acquisition time for the diagnostic sequence was 1.5 seconds per slice. Optic nerve diameters decreased from anterior to posterior and with severity of glaucoma as depicted for healthy subjects in Figure 1 and glaucoma patients in Figure 2. Measurements are given in Table 1.

TABLE 1	**Stage 0**	**Stage I**	**Stage II**	**Stage III**
anterior (mm)	3,11	3,19	2,89	2,82
mid (mm)	2,66	2,66	2,43	1,98
posterior (mm)	2,64	2,48	2,26	1,91

The diameter of the optic nerve 10 and 15 mm behind the eye demonstrated significant correlation with ophthalmologic glaucoma tests.

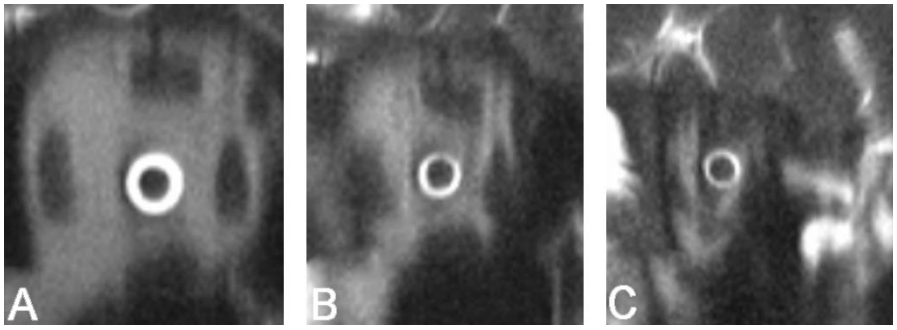

Figure 1: HASTE images for morphometry of the retrobulbar human optic nerve in straight view at 5 mm (A), 10 mm (B) and 15 mm (C) behind the eye. The bright liquor ring is well delineated and exhibits a high contrast to its surrounding tissue.

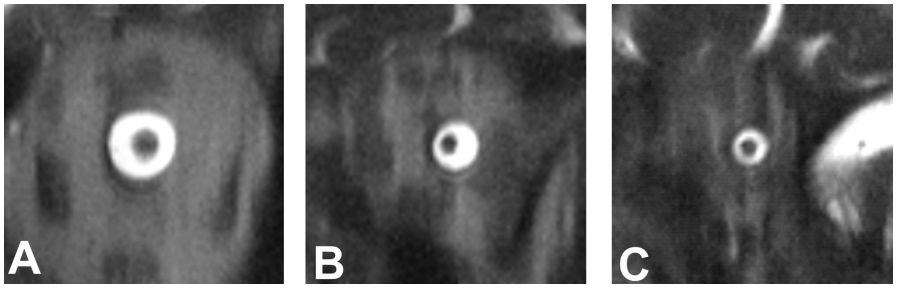

Figure 2: HASTE images in a patient with glaucoma. Please note decreased diameter of the ON and increased thickness of CSF layer.

Discussion: High-resolution MRI at 3.0 T depicts the optic nerve and its sheath within the full intra-orbital track with high contrast in 1.5 sec. acquisition time per slice. In addition to the high contrast between CSF and nerve parenchyma the main advantage of HASTE-sequences is their unprecedented short acquisition time avoiding blurring by uncontrolled eye movements. Imaging findings correlated well with severity of glaucoma. MRI is feasible to investigate the retro-bulbar optic nerve complex and may be useful for quantifying axonal loss within the optic nerve and for assessment of differential diagnoses in optic nerve disease.

References

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