Magnetic resonance imaging of normal and pathological white matter maturation

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Abstract. Fifty children between 3 months postnatal and 16 years of age were examined by means of a 1.5 T superconductive magnet, run at 0.35 and 1.0 T. The myelination was studied qualitatively and quantitatively (relaxation times, proton densities, image contrast). With increasing age, a decrease of T1 and proton density of white matter was found, which was complete at one year of age. In regions with a slow progression of myelination, gray/white matter contrast showed an increase up to the end of the first decade. Pathological white matter maturation was diagnosed either as an abnormal transformation of myelin (characterized by abnormal relaxation values), or as a deficient or delayed myelin formation (in comparison with age-matched controls).

Materials and methods

Fifty children (24 male, 26 female) aged from 3 months postnatal to 16 years were examined. MR images were obtained by a 1.5 T superconductive magnet (Magnetom, Siemens) operating at 0.35 T (35 patients) and 1.0 T (15 patients). A 30-cm head coil was used in all cases. T1- and T2-weighted spin echo (SE) sequences were applied to all children. In half of the cases additional inversion recovery (IR) sequences and/or proton density weighted SE sequences (TR=4s/TE=30 ms) were employed. Only transverse slices with a thickness of 10 mm were used for the evaluation. Under the age of 5 years the children usually required sedation with rectal chloral hydrate (75-100 mg/kg) or chlorprothixene (1 mg/kg) i.v.

Quantitative data were gained from four regions of gray matter (frontal, occipital, caudate nucleus, lentiform nucleus) and
T1 relaxation times of gray and white matter as a function of age at 0.35 T

Fig. 2

T2 relaxation times of gray and white matter as a function of age at 0.35 T

Fig. 3

T1 relaxation times of subcortical and internal capsule white matter at 0.35 T

Fig. 4

Results

Relaxation times

In Figs. 2 and 3 the T1- and T2-relaxation times at 0.35 T are shown as a function of age. Each dot in

from seven regions of white matter (frontal, occipital, corpus callosum, anterior and posterior limbs of internal capsule, cerebellar peduncles, centrum semiovale). The Regions-Of-Interest (ROI) were carefully chosen to minimize partial volume effects. In some children only part of the ROI's could be evaluated because of motion artifacts or registration errors.

For each region, the T1 and T2 relaxation times and the proton density were calculated using the SE equation [4]. In addition, the image contrast-to-noise ratio between gray matter and the different white matter tracts was evaluated according to the equation [5, 6],

$$C = \frac{S_{GMR} - S_{WMR}}{S_{Noise}}$$

The qualitative assessment of white matter myelination was based on the visibility and the extent of white matter tracts.

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