Signal intensity of the motor cortex on phase-weighted images at 3T

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PURPOSE:

The previous studies have reported the effect of aging on the signal intensity of the motor cortex on T2-weighted images, which are attributed to differences in nonheme iron concentration (1). The iron staining was more observed in the motor cortex than other cortices since birth (2). Recently, the susceptibility-weighted imaging, which is obtained by multiplication of the phase images and magnitude images, has been proposed (3). It is expected that this technique would have higher sensitivity for nonheme iron in the motor cortices. The purpose of our study is to assess the signal intensity of the motor cortices on the phase-weighted imaging at 3T MRI, using a Windows-based software we developed.

MATERIALS AND METHODS:

All studies were performed with a 3T MR system (Signa EXCITE 3T;GE Medical Systems, Milwaukee, Wis) by using a dedicated eight-channel phased-array coil. The phase-weighted imaging consisted of a 3D fast SPGR sequence, which was acquired with parameters of 55/700/5 minutes (repetition time msec/ inversion time/imaging time), a flip angle of 20, a bandwidth of 15 kHz, a 22 cm field of view (FOV), a 288 x 128 matrix, and 2-mm thick sections, which resulted in a voxel size of 0.8 x 0.5 x 2.0 mm3. The phase image was low pass filtered (by using a 32 x 32 exclusion of low-spatial-frequency information) to remove much of the brain's low spatial-frequency background static-field variation. A phase mask was created by setting all positive-phase values (between 0° and 180°) to unity and normalizing the negative-phase values ranging from 0° to 180° to a gray scale of values ranging linearly from 1 to 0, respectively. This normalized phase mask was multiplied nine times against the original magnitude image (3). Finally, a minimum intensity projection (mIP) over two sections was performed to display the processed data by using contiguous 4-mm-thick sections in the transverse plane. These images were created by the Windows-based in-house software developed for research purpose.

Before the clinical examination, to investigate the effects of varying TE on the gray-to-white matter contrasts with the three different modalities (magnitude image, phase image, and phase-weighted image), the volunteer study was performed with three healthy volunteers. Within each subject, the phase-weighted image sequence was repeated with different TEs of 12, 28, 40, and 80 msec; all other imaging parameters were kept constant. The results of the volunteer study showed that the gray-to-white matter contrast increased by increasing the TE on phase-weighted image with mIP (Figure 1). The heightened contrast between motor and other cortices is most apparent with 40msec TEs. Therefore, we used the TE of 40 msec in the clinical examination. The clinical study population consisted of 45 subjects (23 women, 22 men: mean age 32.1 years; age range, 9-59 years, age distribution; 9-7years [n=2], 10-19 years [n=8], 20-29 years [n=11], 30-39 years [n=10], 40-49 years [n=7], 50-59 years [n=7]), who have normal findings at neurologic examination and normal results of brain MR image. By conference of two neuroradiologists, the signal intensity of motor cortices was divided into three grades compared with that of superior frontal cortex (SFC): grade I, the signal intensity of the motor cortex is equal to that of SFC; grade II, the contrast in signal intensity between the motor cortex and SFC is slightly visible; grade III, the contrast in signal intensity between two cortices is definitely visible.

RESULTS:

The results of the grading of 90 motor cortices (45 subjects) on three images are summarized in Figures 2. In all subjects older than 20 years, the motor cortex on phase-weighted images was classified as grade II or III. It is interesting to notice that the grade II or III appearance was found 14 (88%) of 16 motor cortices (8 patients) at age 10-19 years. At age 10-39 years, the frequency of grade III appearance was higher at phase-weighted images (45 [78%] of 58 cortices) and phase image (30 [52%] of 58) than at magnitude image (14 [24%] of 58).

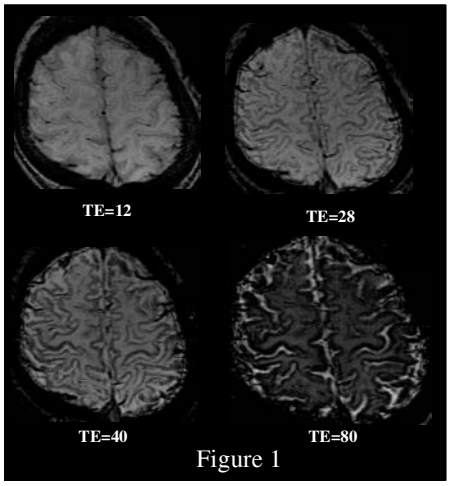

Figure 1

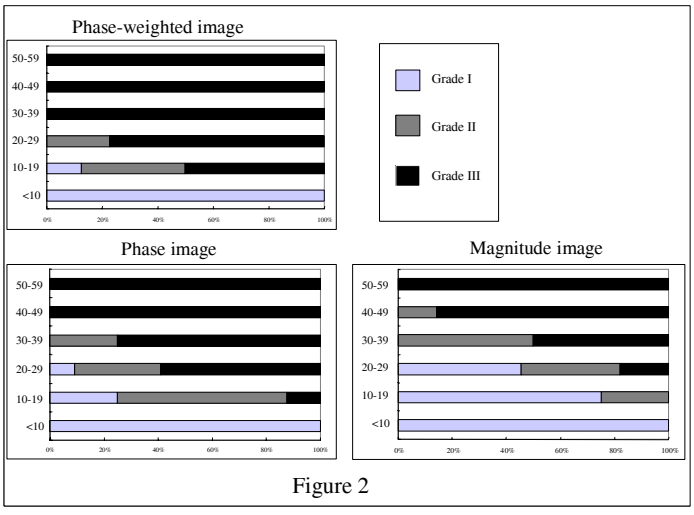

Figure 2

CONCLUSION:

The distinct contrasts between the motor cortices and other cerebral cortices were observed even in the adolescents with use of the optimized echo time, probably due to the great sensitivity of the phase-weighted images for nonheme iron concentration. Other factors, such as the water content of brain tissue, cellular composition, and vascularization of the motor cortex, might also affect the phase shifts. The phase-weighted MR imaging would yield additional information for the early development of neurological disorders which affect the motor cortices.

References:

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