Imaging optimization for in-vivo human micro imaging at 7T

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[Introduction]

Ultra high field MRI for human study became available and its application research is under way. High spatial resolution imaging is one of the promised targets for ultra high field MR because of its high SNR. However, imaging technique for human brain micro imaging in vivo has not been optimized yet. In this study, human study safety on RF power deposition was evaluated and imaging protocol optimization follows.

[Materials and Methods]

FDTD simulation was performed to evaluate local head SAR assuming continuous irradiation. The average SAR maximum limit was determined from the estimated local SAR not to make the induced local SAR in human head exceed IEC 60601-2-33 normal operation mode upper limit in 6min average. RF pulse power applied to human was also monitored with equipped RF power meter in real time. T1 was measured with inversion recovery Spin echo EPI and T2 was measured with multiple echo Spin Echo to get optimum scan parameters. To achieve high spatial resolution less than 100μm in localized FOV, small FOV with phase encode oversampling method, Signal Saturation outside of FOV, and PRESS localized excitation were compared. As increasing spatial resolution, brain subtle motion caused by pulsation became more severe. To compensate this pulsation motion artifact, peripheral gating was used and trigger delay from peak peripheral signal was optimized. Fast Spin Echo (FSE) pulse sequence was used to avoid susceptibility effect at ultra high field. Conventional FSE pulse sequence and FSE equipped with Variable Rate Selective Excitation (VERSE) technique were compared on tissue contrast, required power and image shading. Phantom and volunteer experiment were performed on 7T MRI scanner (SIGNA 7T, GE Healthcare) with 8channel phased array head coil [1]. Coil was driven in single channel receive mode for high spatial resolution localized imaging. All human studies were performed with IRB compliance.

[Results and Discussion]

T1 relaxation time was about 1300ms in white matter and 1700ms in gray matter. T2 relaxation time was about 40ms in white matter and about 45ms in gray matter. These results were comparable with the previous publication[2]. Figure.1 shows SAR simulation result by FDTD. This result shows some high SAR spot could be generated in 7T human scanning. Local SAR peak value was 5.6 times higher than average SAR value. Average SAR limit was modified to 1.79 W/kg, which corresponded to IEC 60601-2-33 head local SAR normal operation mode upper limit, 10 W/kg. For localization, PRESS method and Saturation band method suffered from B1 inhomogeneity and signal outside of the localized FOV was not suppressed completely and that generated artifact in the localized FOV. Delay time of 300ms from peak peripheral signal was optimum to reduce motion artifact by pulsation. Figure.2 shows relation between Transmit power and signal intensity at different location in brain. The result presented that FSE with VERSE was more effective excitation for human brain imaging comparing to conventional FSE. Optimized scan protocol parameters are TR of around 4000ms (depends on heart rate), FOV25mm, 512x256, four times phase encode oversampling and slice thickness was 3mm. With this protocol, 50mm in-place spatial resolution was achieved. ETL of 4 was optimum echo train length and total scan time was 15min. Longer ETL generated blurring, and shorter ETL tended to generate motion artifact due to longer scan time. Figure.3 shows a typical high spatial resolution image with the optimized imaging method. VERSE-FSE constantly generates good tissue contrast between white matter and gray matter. It also reduced SAR by factor of 2 comparing to conventional FSE. The conventional FSE sometimes suffered from SNR and low tissue contrast for some volunteers. This may come from limited peak power for 180 degrees pulse in FSE. Effective TE increase due to variable rate sampling was less than 2ms and it did not affect to image contrast. Combination of Transmit receive coil and phased array receive coils enabled to acquire whole brain reference image with phased array coils to set small FOV and to acquire small FOV image with one small receive coil.

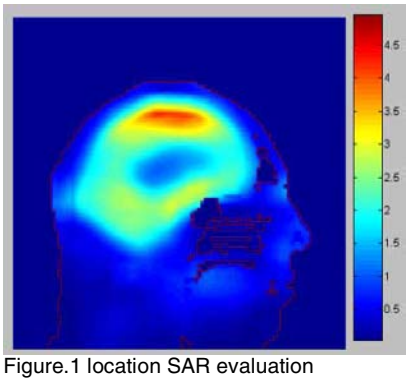

Figure.1 location SAR evaluation by FDTD simulation

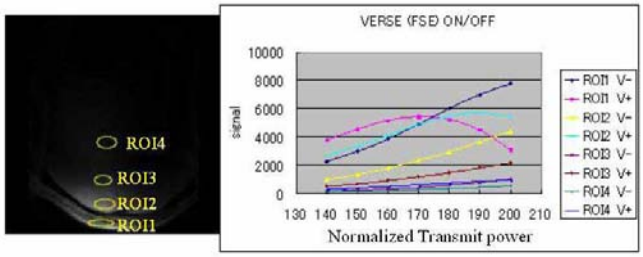

Figure.2 relation between transmit power and signal intensity in FSE

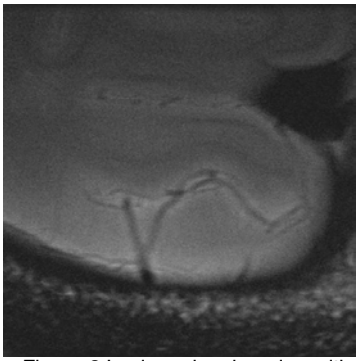

Figure.3 In vivo micro imaging with 50um spatial resolution.

[Conclusion]

We could optimize imaging method to acquire 50μm spatial resolution at 7T within reasonable time.

[Acknowledgement]

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[Reference]

[1] A.Nabetani et al. ISMRM 13th meeting,2005,#932 [2] Quantitative MR I of the Brain, Edited by Paul Tofts, John Wiley & Sons, Ltd.