"Spin-echo Like T1 Contrast" Volumetric Black-Blood Images Using 3D LOWRAT: Low Refocusing Flip Angle TSE.

M. Yoneyama[1], M. Nakamura[1], T. Tabuchi[1], A. Takemura[2], and J. Ogura[1]
[1]Medical Satellite Yaesu Clinic, Chuo-ku, Tokyo, Japan, [2]Philips Electronics Japan, Ltd., Minato-ku, Tokyo, Japan

Introduction:

T1 contrast is typically acquired using multi-slice two-dimensional spin-echo (2D SE), inversion recovery fast spin echo (T1 fluid-attenuated inversion recovery : T1FLAIR) or 3D T1-weighted spoiled gradient-echo (3D T1TFE) imaging [**1**]. However, these conventional methods have problems when used for contrast enhancement studies. 2D-SE requires long scan time for 3-plane diagnosis, resulting in ghosting flow artifacts. T1FLAIR has a low sensitivity to contrast agents. 3D T1TFE captures high signals from small vessels. As a solution to these problems, 3D variable refocusing flip angle turbo spin echo (3D VRFA-TSE) imaging is used recently [**2,3**]. 3D VRFA-TSE decreases flow artifacts by sequence-endogenous flow-void enhancement. However, 3D VRFA-TSE does not bring good T1 contrast due to long echo train and pseudo steady-state effects, thus 3D VRFA-TSE was originally used to acquire T2 contrast [**4**]. In this study, we propose a new scheme of "T1-optimized" black-blood 3D TSE pulse sequence with low refocusing flip angles.

Methods:

Volunteer experiments were acquired by 3D VISTA (**V**olume **IS**otropic **T**SE **A**cquisition) with refocusing flip angle control (**LOW R**efocusing flip **A**ngle VIS**T**A: LOWRAT) using a 3.0 Tesla (T) whole-body clinical imager (Achieva, Philips Medical Systems, Best, the Netherlands). We evaluated two areas; contrast optimization and comparison.

a) Contrast optimization: We performed this on six subjects. All data were acquired by 3D LOWRAT to assess the effect of T1 contrast. The examined imaging parameters were: 1) refocusing flip angles , 2) Pseudo steady-state preparation (Ninety-Plus-Half-Alpha: NPHA preparation (90˚excitation-"90+α/2"-α-α-α-α-) [**5**], and asymptotic preparation (90˚excitation-α1-α2-α3-α4-α-α-) [**6**], 3) excitation flip angles , 4) echo train length (ETL), 5) effective TE / startup echoes (best echo number for the center of K-space), and 6) TR.

b) Contrast comparison: The conventional T1W 2D SE sequence was performed with the same FOV, slice locations and acquisition matrix as 3D LOWRAT. Acquisition parameters for T1W 2D SE were TR/TE=500/10ms, FA=80°. CNR measurements between grey matter and white matter (GM-WM), and grey matter and CSF (GM-CSF) were used to compare 2D SE and optimized 3D-LOWRAT. CNR measurements were performed at the same anatomical location for 2D SE and 3D LOWRAT.

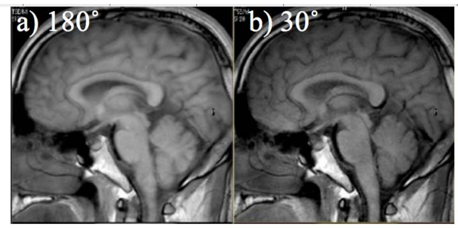

Fig. 1 Comparison of a) 180˚ and b) 30˚ refocusing flip angle VISTA. Imaging parameter: TR=400ms TE=10ms excitation FA=75˚ ETL=16.

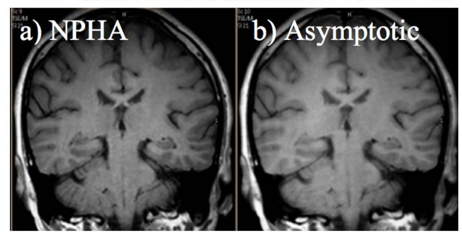

Fig. 2 Comparison of a) NPHA and b) Asymptotic PSS preparation. Imaging parameter: TR=400ms TE=10ms FA=75˚ RFA=40˚ ETL=16.

Results and Discussion:

a) The optimal parameter for T1-optimized black-blood imaging was 1) low refocusing flip angles (recommend the 30-50°) to increase flow-void effect (decreasing flow artifacts in post contrast-enhanced) and to decrease image blurring **[Fig.1]** , 2) choose NPHA pseudo steady-state preparation to decrease T2 relaxation effect and magnetization transfer (MT) effect **[Fig.2]** ,3) low excitation flip angles (recommend the 60-75°) to decrease MT effect [**7**] **[Fig.3]** , 4) short ETL (recommend 15-20) to decrease T2 relaxation effect and MT effect **[Fig.4]** , 5) best echo number for the center of K-space was the 2nd echo (effective TE was 2x echo-spacing), and 6) shortest TR (recommend 350-400ms) to save scan duration.

b) Based on these results, we used optimized parameters for T1W contrast comparison with 2D SE. Contrast behavior of 3D LOWRAT T1W was similar to that of 2D SE.

Fig.5 shows the pre- and post- contrast enhanced 1mm isotropic T1-weighted black-blood images by "optimized" 3D LOWRAT sequences. Imaging parameters were: 3D VISTA, sagittal plane, FOV=256mm, matrix=256x256, slices=224, slice thickness=1mm (no slice ZIP), 2D SENSE (Phase reduction=2.0, Slice reduction=1.6), TR=400ms, TE=9.2ms (echo-spacing=4.6ms), excitation FA=65°, refocusing FA=40°, NPHA pseudo steady-state preparation, ETL=16. Total scan duration was 5:37.

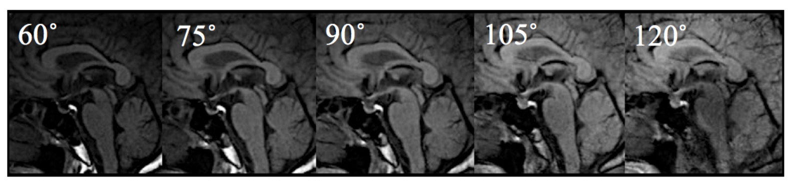

Fig. 3 Influence of excitation flip angles in T1 contrast behavior. Imaging parameter: TR=400ms, TE=10ms, RFA=40˚, ETL=16.

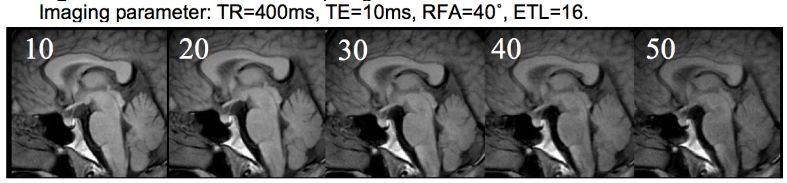

Fig. 4 Influence of echo train length in T1 contrast behavior. Imaging parameter: TR=400ms TE=10ms, FA=75˚, RFA=40˚.

Conclusion:

This study showed the new scheme of "T1-optimized" black-blood 3D TSE pulse sequence with low refocusing flip angles. This optimal sequences can be used for 3D volumetric T1 weighted black-blood imaging. And may also be used for detecting brain metastasis, and potentially plaque characterization in vessel wall imaging. Further investigation is needed for clinical evaluation and limitation.

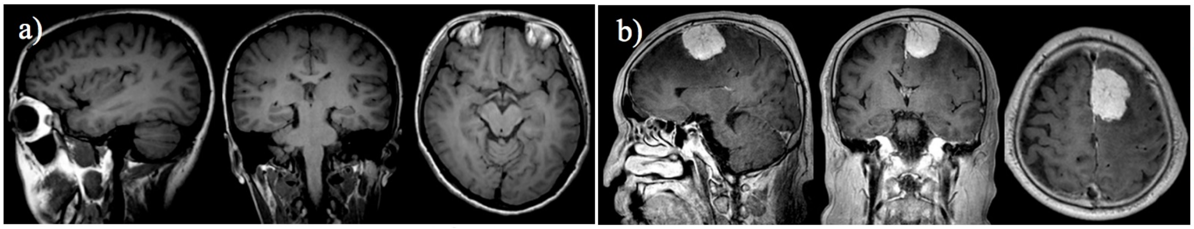

Fig. 5 a) pre- and b) post contrast enhanced 1mm isotropic T1-weighted black-blood images by optimized 3D LOWRAT. (3mm-MPR images)

References:

(1) Kakeda, Eur Radiol 17, 2345-2451 (2007); (2) Komada, MRMS 7, 13-21 (2008); (3) Kato, AJNR 30, 923-929 (2009); (4) Hennig, MRM 49:527-535 (2003); (5) Hennig, MRM 44:983-985 (2000); (6) Alsop, MRM 37:176-184 (1997); (7) Schmitz, AJNR 26:2000-2004 (2005).