OPTIMIZATION OF GRADIENT MOMENT NULLING FOR HYBRID OF OPPOSITE-CONTRAST MRA SEQUENCE

T. Kimura[1], and M. Ikedo[1]
[1]MRI Systems Development Department, Toshiba Medical Systems, Otawara, Tochigi, Japan

Introduction

To enhance slower arterial flow as well as faster flow without increasing imaging time, we have proposed a new MRA technique named hybrid of opposite-contrast MRA (HOP-MRA) that combined standard TOF white-blood (WB) MRA with the flow-sensitive black-blood (FSBB) sequence, resulting in excellent visualization of slow-flow vessels, as compared to the MTC-TOF MRA technique [1,2]. However, flow-void artifacts were notable especially in major brain arteries in the HOP-MRA technique. This was hypothesized to be due to the difference of gradient moment nulling (GMN) in the 1st echo (TOF) part of the sequence. "Phase-encode displacement (PED) artifacts" [3] are well known, in which blood vessels are shifted from the original position depending on velocity, angle between flow and read-out, and gradient shape in a spin warp GRE-based sequence. A full-velocity compensation (3-axis GMN) was employed in the TOF part of the HOP-MRA sequence to reduce the PED artifacts. A standard MTC-TOF sequence employed the GMN in k-space center in the two phase-encode directions (2-axis GMN). The purpose of this study was to assess flow-void artifacts and the degree of PED artifacts due to the GMN difference in TOF part in HOP-MRA.

Methods

Simulation for the PED artifacts was performed based on Nishimura's method [3]. Simulation conditions were: time interval between center of phase-encode pulse and the echo peak (deltaT) was 2.85ms, radius (R) of blood-vessel was 3mm and the flowing direction was 45deg that provides a maximum displacement from the read-out direction (X) (**Fig. 1a**). Imaging was performed on a 1.5-T whole-body imager (EXCELART Vantage™, Toshiba Medical Systems Corp.). Dual-echo 3D-gradient-echo sequence (FE3D) and parallel imaging with a reduction factor of 2 were employed. In the 1st echo for TOF, TE=6.4 ms and 1st order GMN was employed. In the 2nd echo (for FSBB), TE=24 ms and flow dephasing gradient of b=2 s/mm^2 were employed. Volume images for HOP-MRA were obtained by simple-weighted subtraction using TOF signal, S_{TOF} and FSBB signal, S_{BB} as $S_{HOP}=S_{TOF}-a*S_{BB}$ and the scaling coefficient a=1.5 was used. Maximum intensity projection (MIP) was performed without volume selection. Two types of TOF with 3-axis GMN and 2-axis GMN for generating HOP-MRA were compared in simulation and in a volunteer study.

Results and Discussion

Simulation results showed that vessel walls remained within the ideal vessel positions at velocities below 50 cm/s, though the distortions of vessel profiles were pronounced in higher velocities (**Fig. 1b**). Flow void artifacts in the HOP-MRA using TOF with 3axis-GMN were decreased by using TOF with 2-axis GMN (**Fig. 2**). This was likely due to dephasing effects induced by higher order moments over 2nd order. Vessel shift artifacts were pronounced in the TOF-MRA with 2-axis GMN but the vessel width remained within the original vessel walls similar to the results of the simulation. Those artifacts, however, were decreased in the HOP-MRA even with the 2-axis GMN due to the contribution of FSBB signal, and the width between vessel walls in the HOP-MRA was almost similar to that with the 3-axis GMN and FSBB where realistic profiles were probably provided. (**Fig. 3**). Considering less flow-void artifacts and minor vessel shift artifacts, 2-axis GMN is better for the TOF part on HOP-MRA sequence. The HOP technique is suitable for decreasing both flow-void and PED artifacts in MRA compared to TOF alone.

References

[1] Kimura T et al. MRM62: 450-458 (2009).
[2] Kodama T. at al.: Proc of ISMRM, p3416, 2008.
[3] Nishimura et al. MRM 22, 481-492, 1991.

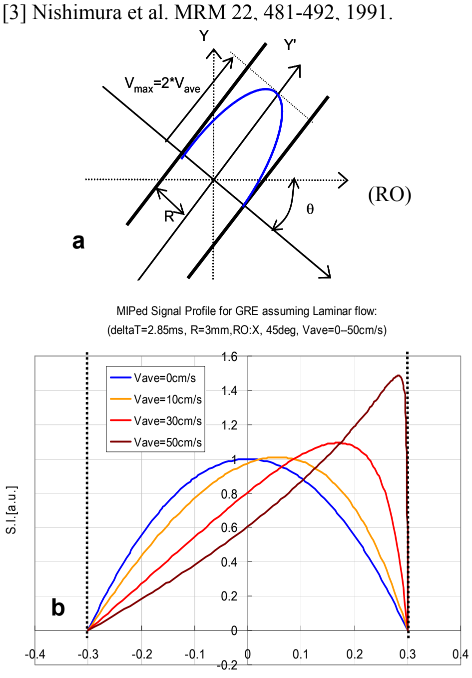

Fig. 1. Simulated vessel MIPed profiles as a parameter of V_{ave} in GRE–based TOF MRA, where θ of 45deg provided the maximum shift.

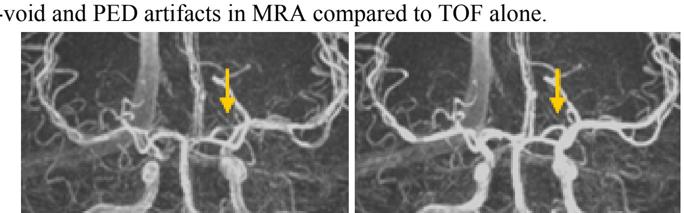

Fig. 2. Flow–void artifacts (arrows) shown in the HOP-MRA using TOF with 3-axis GMN (left) were decreased by using TOF with 2-axis GMN (right).

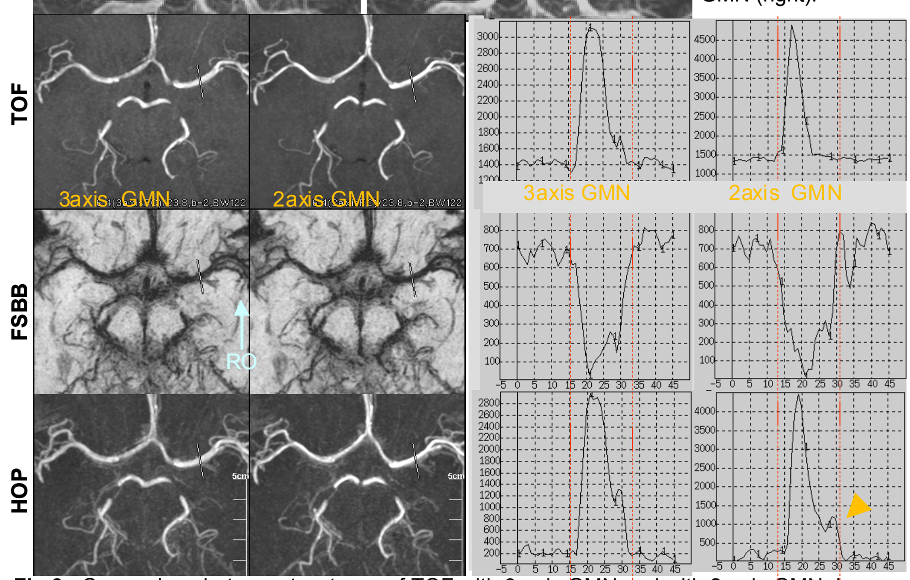

Fig.3. Comparison between two types of TOF with 3-axis GMN and with 2-axis GMN. Images with MIP (TOF and HOP), and mIP (FSBB) and those profiles on the 1st branch of the MCA were shown. Vessel walls in the HOP images were maintained in the correct position even with the 2 axis-GMN (arrow). Note that the vertical scales are different.