Noncontrast MRA at 3T

M. Miyazaki[1,2], Y. Yamashita[2], A. Wheaton[1], W. Dannels[1], R. Anderson[1], L. Zha[1], and S. Sugiura[2]

[1]Toshiba Medical Research Institute USA, Vernon Hills, IL, United States, [2]Toshiba Medical Systems, Otawara, Tochigi, Japan

PURPOSE:

Despite the recent advancements in 3T, non-contrast MRA faces many problems such as a specific absorption rate (SAR) and B1 inhomogeneity. At 3T, a common method to comply with SAR limitations is to reduce RF excitation and refocus pulse flip angles. However, this approach makes it difficult to maintain bright blood signal necessary for MRA applications. In addition, the B1 wavelength effect caused by conventional quadrature RF transmission makes shading or nonuniform signal intensity unavoidable. This shading effect is problematic especially in the iliac and peripheral areas [1]. In this study, we adjusted the pulse sequences to lower SAR and addressed the signal shading issue by applying multi-phase RF transmission (2 channels with 4 ports).

MATERIALS and METHODS:

All studies were performed on healthy volunteers using a clinical 3T unit (Vantage Titan™ Toshiba, Japan) and a research unit. The non-contrast MRA studies were performed in abdominal and peripheral run-offs using time-spatial labeling inversion pulse (time-SLIP) [2] and fresh blood imaging (FBI) using ECG gated 3D half-Fourier FSE [3], respectively. The effects of RF flip angle were studied and optimized to lower the SAR on both 3D half-Fourier FSE and 3D balanced SSFP (bSSFP) sequences. To study the effect of B1 shading, both time-SLIP and FBI were evaluated on the femoral region with and without B1 shimming.

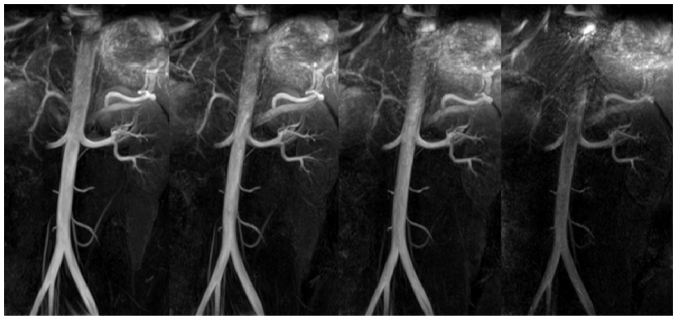

Fig. 1 Flow-In 3D time-SLIP bSSFP with different flip angles

RESULTS:

The effect of RF flip angles was shown in the noncontrast time-SLIP bSSFP renal MRA in Fig. 1. As the flip angle is decreased, the bright blood signal is reduced. A similar signal drop was observed in the FBI images using lower refocusing angles (not shown). Figure 2 shows the B1 transmit map without and with B1 shimming (top row). The peripheral FBI image shows a significant shading effect without B1 shimming whereas both femoral arteries were evenly depicted with B1 shimming (Figure 2). In addition, aorta-iliac to femoral FBI (Figure 3) shows good contrast without any shading using the refocusing flip angle of 140 deg, TR=4 RRs, TEeff=80 ms, and PI factor of 4. Figure 4 shows a comparison of renal MRA using time-SLIP at 1.5T and 3T on the same healthy volunteer.

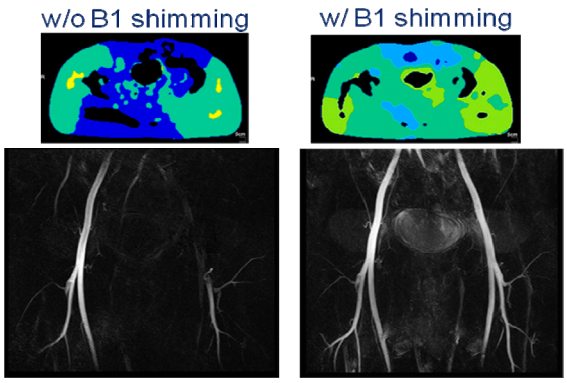

Fig. 2 RF Map without and with B1 shimming (top). Femoral FBI images without and with B1 shimming (bottom).

DISCUSSION:

As compared to 1.5T, 3T noncontrast MRA has higher signal; however, blood signals can be sensitive to B1 inhomogeneity and choice of flip angles. In order to gain blood to background contrast, flip angles must be optimized within SAR restrictions. Multi-phase transmission using 2 channels with 4 ports effectively addresses the B1 shading problem producing uniform of blood signal across the FOV in abdominal and peripheral MRA.

Renal MRA using time-SLIP shows better delineation of the renal branches. The longer T1 at 3T allows for a longer black blood inversion time (BBTI), thus enabling a longer duration for inflow into the renal branches while maintaining good background suppression. In the peripheral run-offs, the femoral and calf FBI images present high arterial signal intensity enabling better depiction of small branch arteries. In the iliac region, with the application of multi-phase transmission, both the right and left femoral arteries in FBI images show uniform signal intensity without shading. However, further optimization is required to reduce scan time or increase spatial resolution.

Fig. 3 Aorto-iliac to femoral FBI images using adjusted RF refocusing pulses without shading using multi-phase transmission.

CONCLUSION:

The optimized FBI and bSSFP sequences generate high arterial signal intensity within SAR limitations. The longer T1 at 3T can be leveraged to increase inflow signal in combination with better background suppression in time-SLIP renal MRA. Multi-phase RF transmission sufficiently mitigates the B1-related signal shading issue for MRA.

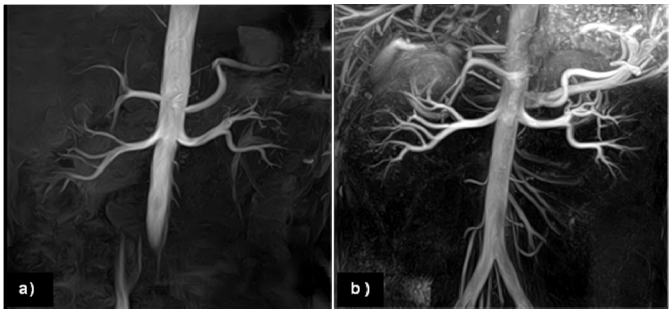

Fig. 4 Renal time-SLIP acquired at 1.5T a) and 3T b). a) TR/TE=5.2/2.6, FA=120, TI=1500, STIR=190, PI=2.0. b) TR/TE=4.8/2.4, FA=115, TI=1500, STIR=250, PI=3.0

REFERENCES:

1] Storey P, et al, ISMRM p425, 2009

2] Kanazawa H and Miyazaki M. ISMRM p140, 2002.

3] Miyazaki M, et al, Radiology 227:890-896, 2003.