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Oral presentation

3D nongadolinium-enhanced mra using flow-sensitive dephasing (fsd) prepared balanced ssfp: identification of the optimal first-order gradient moment

Zhaoyang Fan*[1], Xiaoming Bi[2], Xiangzhi Zhou[1], Sven Zuehlsdorff[2], James Carr[1] and Debiao Li[1]

Address: [1]Northwestern University, Chicago, IL, USA and [2]Siemens Medical Solutions, Chicago, IL, USA

* Corresponding author

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Introduction

A noncontrast MRA technique using ECG-triggered 3D bSSFP with FSD preparation has recently been developed (Fig. 1) [1]. The angiographic quality relies on the blood signal suppression by FSD preparation, which is in turn determined by FSD's first-order gradient moment, m_1. A suboptimal m_1 may result in venous contamination or incomplete arterial delineation. This work aimed to develop an m_1-scout approach to rapidly identify the optimal m_1-value.

Materials and methods

Theory

For a FSD-based 3D isotropic resolution MRA with major flows along the readout direction, we hypothesized that the same imaging sequence can be switched to a 2D mode to rapidly identify the optimal m_1 as applied in the readout direction during the 3D dark-artery measurement. This requires the 2D imaging plane be perpendicular to the major vessel of interest, the FSD gradient pulses applied in the slice-select direction, and the in-plane resolution identical to that of 3D MRA.

Imaging

(1) Flow phantom study (Gd-doped water 0.25 mM). Six flow rates (15, 20, 30, . . 60 cm/s) were tested. A 2D FSD-bSSFP scan, as m_1-scout, acquired 11 images with incremental m_1 values (0.9-mm in-plane and 5-mm slice-thickness) (Fig. 2). 3D FSD-bSSFP imaging was repeated with 6 selected m_1-values (0.9-mm isotropic). (2) Volunteer study (3 M, 2 F). Left and right thighs were scanned separately. 2D m_1-scout imaging employed m_1 = 0, 5, . . 50 mT·ms²/m, respectively. 3D FSD-bSSFP imaging was repeated with 7 selected m_1-values.

Results

The 2D scout took <1 min as opposed to 4-5 min required for 3D MRA. In the phantom study, the lumen signal intensity from the 2D and 3D images were significantly correlated at all the velocities tested (Pearson correlation = 0.988 ± 0.011, p < 0.001) (Fig. 3). Similar results were observed in the volunteer study (Fig. 4a, Table 1).

Conclusion

The optimal m_1 value determined by the 2D scout approach consistently offers high-quality MRA at the volunteer extremities (Fig. 4b, 5, 6). FSD-induced signal suppression is voxel size-dependent as its underlying mechanism is the intravoxel velocity variation [1,2]. Despite the large pixel size in the 2D scout, this variation is equivalent between the 2D and 3D scans if the velocity is constant along the vessel course. This efficient approach is likely to be beneficial for FSD-based MRA and vessel wall imaging [3].

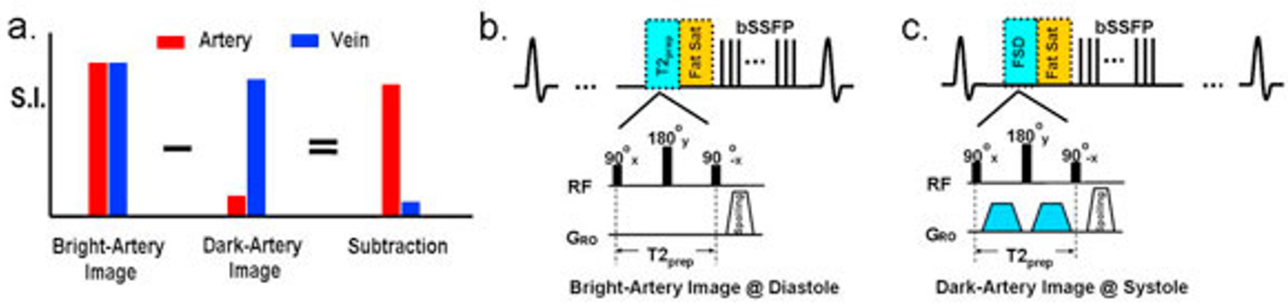

Figure 1
Schematic of FSD-prepared MRA method (a) and sequence diagrmas (b and c).

Figure 2
Schematic of the 2D m_1-scout approach. A total of 11 images were collected within 1 min. The first uses m_1 = 0, while the latter uses incremental m_1 values (user specified)

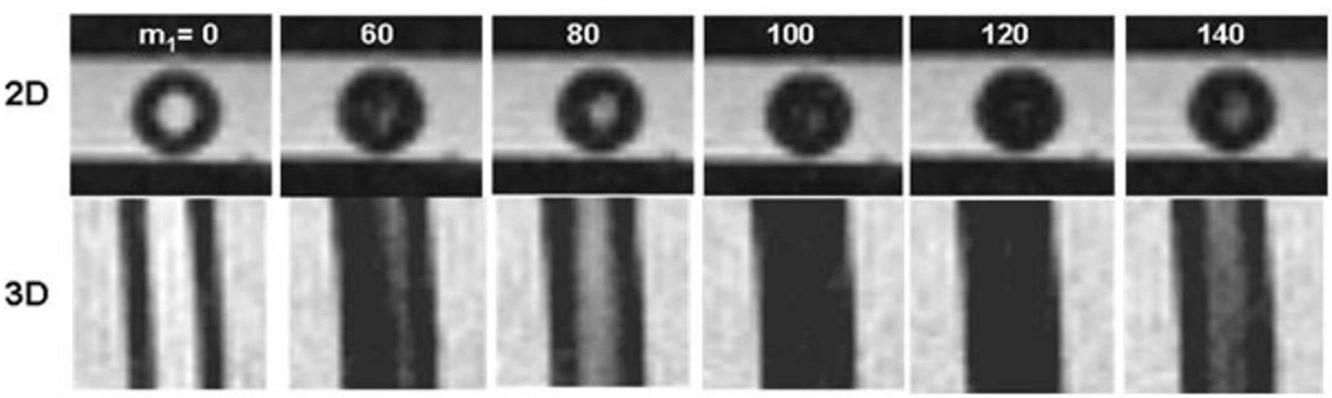

Figure 3
2D scout vs. 3D reformatted images (flow phantom).

Table 1: Signal intensity Pearson correlation in 5 healthy volunteers

Volunteer (Left/Right)	1 (L)	1 (R)	2 (L)	2 (R)	3 (L)	3 (R)	4 (L)	4 (R)	5 (L)	5 (R)
Pearson Correlation	0.941	0.955	0.974	0.984	0.990	0.992	0.947	0.960	0.924	0.950
p-value	0.002	0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001	0.003	0.001

References

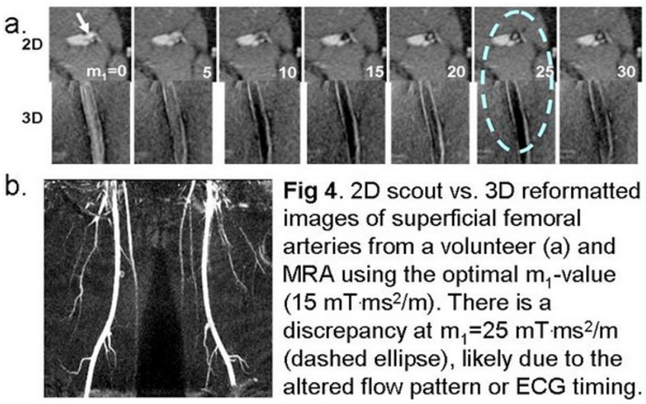

Figure 4
2D scout vs. 3D reformatted images of superficial femoral arteries from a volunteer (a) and MRA using the optimal m_1-value (15 mT ms^2/m). There is a discrepancy at m^1 = 25 mT ms^2/m (dashed ellipse), likely due to the altered flow pattern or ECG timing

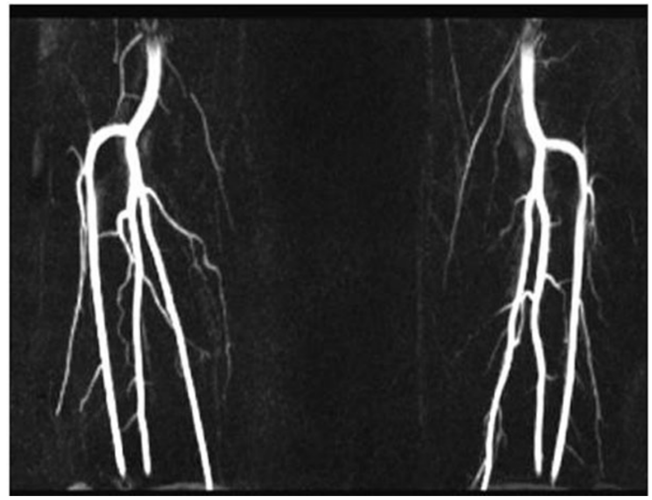

Figure 5
Superior arterial depiction in calf MRA.

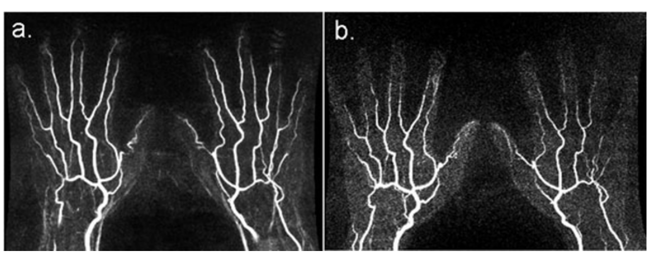

Figure 6
Noncontrast hand MRA (a) has better arterial depiction than contrast MRA (b).