Contrast enhanced carotid vessel wall imaging using DANTE preparation

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Target audience: Radiologists and MR physicists who are interested in black blood carotid vessel wall imaging optimization.

Purpose: Atherosclerotic carotid plaques are one of the main causes of cerebrovascular ischaemic events. High spatial-resolution multi-contrast MRI of the carotid artery vessel wall can visualize high-risk morphological features of plaques in vivo and help patient risk stratification [1]. The use of a gadolinium-based contrast agent improves the accuracy of plaque characterization [2]. Quadruple inversion-recovery (QIR) has been widely used for contrast-enhanced plaque imaging [3]. However, QIR can still present flow artefacts in some situations and it only allows single-slice acquisition. Delay Alternating with Nutation for Tailored Excitation (DANTE) preparation has strong blood suppression ability [4], but its use has not been reported in post-contrast imaging. 3D isotropic imaging of the carotid artery wall is advantageous for its high SNR efficiency, but it has been rarely used post-contrast. In this study we aim to evaluate DANTE in contrast-enhanced MRI of carotid artery wall using 2D T_1w FSE and 3D FSE (CUBE, GE Healthcare) in patients. To our knowledge this is the first study applying DANTE post-contrast.

Methods: (a) Study population: One healthy volunteer and four patient with >30% carotid stenosis identified by ultrasound were recruited for this preliminary study. Three patients underwent 2D T_1w FSE of carotid arteries both pre- and post-contrast using QIR and DANTE preparations. One healthy volunteer also underwent multi-slice DANTE prepared T_1w FSE without contrast-injection. Another separate patient underwent 3D T_1w CUBE imaging of carotid arteries both pre- and post-contrast, without and with DANTE preparation. All examination were performed on a 1.5T system (MR450, GE Healthcare) using a 4 channel phased-array neck coil. **(b) Scan protocol:** 2D T_1w FSE: TR/TE : 750ms/9ms; 14cm*14cm FOV,256*192 matrix, 3mm slice thickness, 4 slices to cover th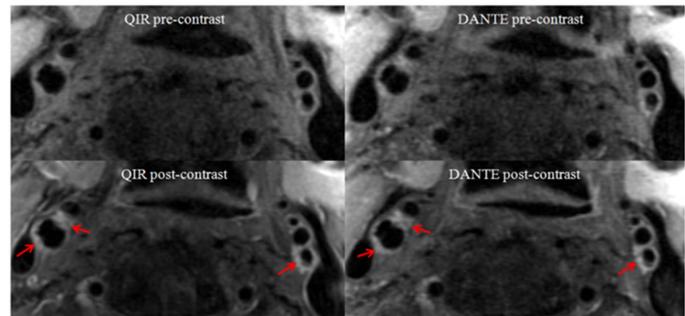e bifurcation; NEX 2; ETL 6. A single slice QIR sequence was prescribed as defined previously [3]. 3D T_1w CUBE: TR/TE: 440ms/10ms; 14cm*14cm FOV; 224*224 matrix; 40 coronal slices; 1.2mm slice thickness (interpolated to 0.6mm); ETL 24. DANTE parameters were adopted from previous publications [5; 6]: train length: 150; RF pulse gap: 1ms; preparation time: 150ms; flip angle of RF pulse: 11°; gradient amplitude: 20 mT/m. Multi-slice DANTE prepared 2D T_1w FSE acquired 1,2,3 slices per TR. **(c) Image and data analysis:** Lumen and adjacent muscle SNR was measured in order to quantify the blood suppression and SNR performance. Paired t-tests were performed to test within group differences in SNR using the different sequences.

Figure 1 2D pre- and post-contrast T_1w FSE of carotid plaque in a patient using QIR and DANTE preparation.

	Muscle SNR mean[SD]	Lumen SNR mean[SD]
2D pre-contrast		
QIR	35.3 [9.3]	6.3 [2.1]
DANTE	37.2 [7.1]	6.7 [2.3]
p-value	0.33	0.21
2D post-contrast		
QIR	42.9 [14.4]	9.5 [3.4]
DANTE	38.1 [12.6]	7.5 [3.7]
p-value	0.0006	<0.0001

Table 1 SNR comparison between QIR and DANTE T_1w FSE.

Figure 2 3D pre- and post-contrast T_1w CUBE of carotid plaque in a patient with and without DANTE preparation. Red arrows show adventitial enhancement. Yellow arrows show calcium.

Results: Both QIR and DANTE can achieve good SNR and adequate blood suppression in pre- and post-contrast imaging (Figure 1 & Table 1). In 2D pre-contrast imaging, DANTE and QIR were comparable. In 2D post-contrast imaging, DANTE significantly improved the blood suppression but slightly reduced the SNR (11.2%). In 3D post-contrast CUBE (Figure 2), DANTE did not improve the blood suppression (lumen SNR: CUBE 4.8 vs. DANTE-CUBE 4.7) but slightly reduced the muscle SNR (24.4 vs. 21.9). In 2D multi-slice DANTE T_1w FSE, muscle SNR reduced with increased slices per TR (1,2,3 slices per TR: 50.7 vs. 44.6 vs. 31.6); also the blood suppression was improved: (lumen SNR in 1,2,3 slices per TR: 6.9 vs. 4.7 vs. 4.2).

Discussion: We proved DANTE preparation could achieve equivalent or better blood suppression with slightly less or comparable image SNR in 2D contrast-enhanced carotid vessel wall imaging with respect to the QIR method. DANTE also enabled multi-slice imaging which could significantly reduce the scan time. Initial testing of pre-contrast imaging in a volunteer showed multi-slice DANTE had an acceptable image SNR loss with improved blood suppression. However this finding needs to be validated in a larger cohort of patients and we are currently testing multi-slice DANTE in post-contrast imaging. In 3D CUBE imaging, we did not observe flow artefacts in the patient due to CUBE's inherent black blood effect. However, DANTE may still be useful in some patients with tortuous arteries or complex flow patterns.

Conclusion: DANTE preparation can improve the blood suppression in 2D contrast-enhanced carotid vessel wall imaging without significantly reducing image SNR. DANTE is also feasible for 2D multi-slice scans to reduce scan time, and has the potential to be used in post-contrast CUBE MRI.

Reference: 1.Underhill et al. Nat Rev Cardiol 7(3):165-173; 2. Wasserman et al. Stroke 41(10 Suppl):S12-16; 3. Yarnykh et al. MRM 48(5):899-905; 4. Li et al. MRM 68(5):1423-1438; 5. Li et al. ISMRM 2012 p3824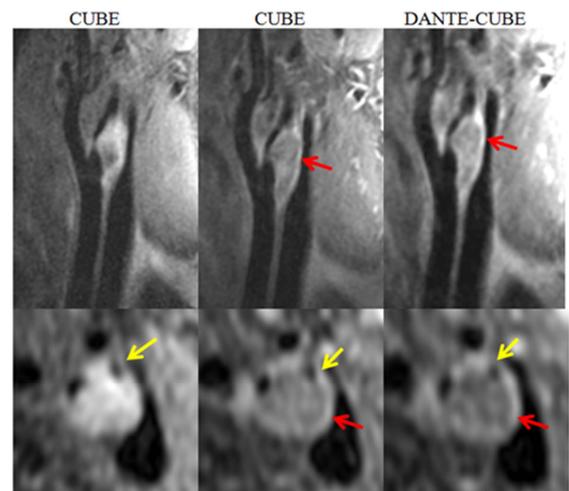; 6. Li et al. ISMRM British Chapter 2013 P64.