A Comparison of Static and Dynamic 3D Magnetic Resonance Angiography for the Diagnosis of Infrapopliteal Disease in Patients using TREAT and iPAT

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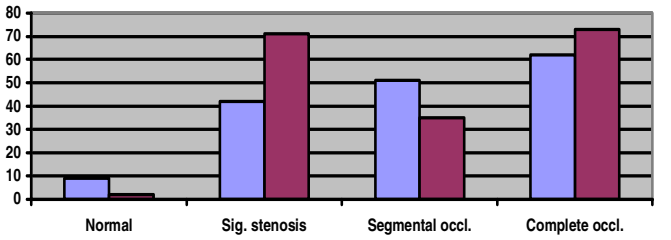
Introduction: Contrast enhanced magnetic resonance angiography (CE-MRA) is increasingly being used as a first-line tool for imaging the vasculature. In general, lower extremity CE-MRA produces static images of the blood vessels with little or no temporal information. To improve temporal resolution, spatial resolution must be sacrificed, which is particularly relevant for infrapopliteal arteries. A number of new acceleration techniques, like time resolved imaging of contrast kinetic (TRICKS), time resolved echo-shared angiographic technique (TREAT), integrated parallel acquisition technique (iPAT), have recently become available resulting in upto four fold increases in imaging speed (1). When these are used in combination, it may be possible to achieve substantial improvements in temporal resolution without any sacrifice in spatial resolution. The clinical benefit of time resolved MRA for diagnosis of peripheral vascular disease has not previously been addressed.

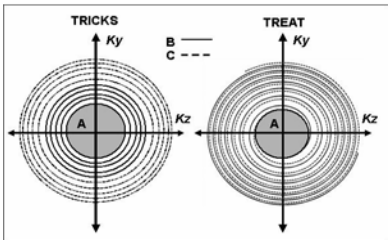
Purpose: To compare high resolution CE-MRA, using a novel time resolved MRA pulse sequence TREAT and iPAT, with conventional static CE-MRA for the assessment of infrapopliteal peripheral vascular disease.

Material and Methods: 47 patients with suspected peripheral vascular disease were studied using the 1.5T Siemens Avanto scanner. A modified hybrid protocol with iPAT and generalized autocalibrating partially parallel acquisitions (GRAPPA) reconstruction (2) was utilized in the pelvis and thigh stations. Infrapopliteal vasculature was imaged with the novel strategy, combining TREAT and iPAT. TREAT is based on the TRICKS concept but uses a different k space trajectory and region sharing scheme (fig. 1). The time resolved frame rates were 5 sec per 3D image set, and the voxel size was 1.2x0.7x1.2 cubic mm. Time resolved dynamic series were compared to a single static frame selected from the dynamic series. The frame immediately following the frame that contained peak popliteal enhancement was chosen as the static frame for comparison. Two blinded readers evaluated the images. The lesions were classified as 1-significant stenosis (>50%), 2-segmental occlusion, 3-complete occlusion without reconstitution, 4-other vascular lesion, and 5-incidental pathology. All infrapopliteal arteries with the exception of the dorsalis pedis artery were studied by dividing them into proximal and distal segments resulting in a total of 14 segments per patient.

Results: Time resolved dynamic MRA produced a 33% change in diagnosis for significant stenosis in the left dorsalis pedis (LDP) artery. The change in diagnosis for segmental occlusion in the right anterior tibial (RAT), left anterior tibial (LAT) , right posterior tibial (RPT), left posterior tibial (LPT), left peroneal (LPE), and LDP artery was 20%, 30%, 33%, 44%, 43%, and 100%, respectively. There was a 55% change in diagnosis for complete occlusion in the right peroneal (RPE) artery (table). The change in diagnosis in the individual artery segments ranged from 14% to 100% in all the segments except the distal RAT, proximal LAT, distal LPE, and the RDP. The change in diagnosis was seen in 64% of the patients. We used the Cicchetti Allison type weighted kappa to find out the agreement between the static and dynamic techniques. The estimated weighted kappa of the total number of lesions across lesion types was 0.70 (95% Confidence Interval (CI): 0.59, 0.82) in the AT, indicating a fairly good agreement between the two methods, 0.60 (95% CI: 0.45, 0.75) in the PT, indicating good agreement, 0.57 (95% CI: 0.41, 0.73) in the PE, indicating good agreement, and 0.50 (95% CI: 0.17, 0.83) in the DP, indicating a moderate agreement between the two methods. The weighted kappa of the total number of lesions across lesion types in all the infrapopliteal arteries was 0.67 (95% CI: 0.55, 0.78), indicating a fairly good agreement between the two techniques.



Artery	Significant stenosis	Segmental occlusion	Complete occlusion
RAT	0%	20%	0%
LAT	0%	30%	0%
RPT	0%	33.34%	0%
LPT	0%	44.45%	0%
RPE	0%	0%	54.55%
LPE	0%	42.86%	0%
LDP	33.34%	100%	0%



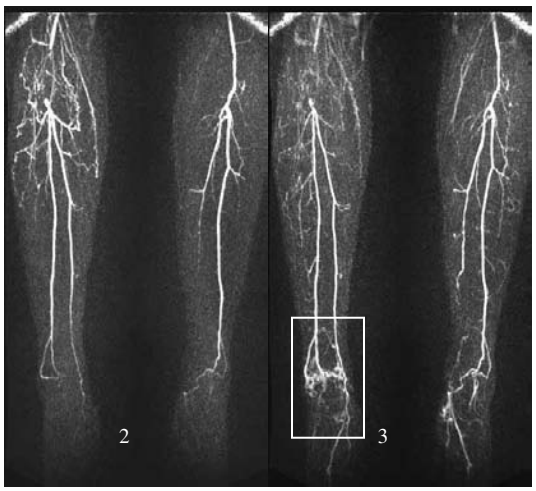


Chart: Total number of lesions including normals seen on conventional static and time resolved dynamic imaging in 47 patients.
Table: Percentage change in diagnosis in the infrapopliteal arteries on dynamic scans.
Figure: Fig. 1 - Comparison of the k-space segmentation schemes of a 3-region (A, B, and C) TRICKS and TREAT pulse sequence. Left-An elliptically centric encoded TRICKS acquisition acquires A, B, and C regions concentrically with the A region covering the central 1/3 of the k-space (solid gray region), the second 1/3 is the B region (solid lines) and peripheral 1/3, the C region (dashed lines). Right-The TREAT sequence defines the A region the same as TRICKS, but interleaved the B (solid lines) and C regions (dashed lines). Fig. 2 - 58 year old male with one block claudication. Time resolved dynamic images showed bilateral, multifocal superficial femoral arterial disease with right tibioperoneal arterial segmental occlusion. Two vessel run-off was seen on delayed frames. Fig. 3 - Time resolved imaging in the same patient as in fig. 2 also revealed enhancement of the right ankle, secondary to incidental arthritis (Box-fig. 3).

Conclusion: Time resolved MRA using TREAT and iPAT produced detailed images of the infrapopliteal arteries with temporal resolution of 5 seconds per frame. Images from time resolved MRA exams included clinically relevant information that can alter diagnosis. Change in diagnosis was due to asymmetric flow, slow flow, and reconstitution of distal runoff vessels on delayed frames, thus identifying a target vessel for surgery, which may result in significant changes in clinical management.

References: 1. Carr JC, et al. ISMRM 2002.
2. Morash M, et al. J Vasc Surg 2003; 37: 62-71.