A Comparison of Static and Dynamic 3D MRA for the Diagnosis of Infrapopliteal Disease in 50 Patients Using TREAT and iPAT

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Introduction:

Digital Subtraction Angiography (DSA) is still regarded by many as the gold standard for evaluating the peripheral arterial tree. One major advantage of DSA is its ability to produce detailed images of vascular structures at rapid frame rates. Contrast-enhanced MR angiography (CEMRA) is increasingly being used as a first-line tool for imaging the vasculature. In general, lower extremity CEMRA produces static images of the blood vessels with little or no temporal information. The reason for this is that, in order to improve temporal resolution, spatial resolution must be sacrificed, which is particularly relevant for the infrapopliteal arteries. A number of new acceleration techniques, i.e. parallel imaging and TREAT (time-resolved echo-shared angiographic technique) [1], have recently become available resulting in up to four fold increases in imaging speed. When these are used in combination, it may be possible to achieve substantial improvements in temporal resolution without any sacrifice in spatial resolution. This may have enormous potential for imaging the infrapopliteal arteries where time-resolved imaging with high spatial resolution becomes feasible, thus approaching some of the capabilities of DSA. The clinical benefit of time-resolved MRA for diagnosis of peripheral vascular disease has not previously been addressed.

Purpose:

To compare time-resolved CEMRA, using TREAT and iPAT, with conventional static CEMRA for assessment of infrapopliteal peripheral vascular disease.

Subjects and Methods:

Fifty consecutive patients undergoing lower extremity MRA for suspected peripheral vascular disease were included in this retrospective study. All studies were carried out on a 1.5 T Siemens Avanto. The lower extremity MRA technique was a modification of the hybrid protocol, which has been described previously [2,3]. There were a number of notable differences. Parallel imaging (iPAT) was used in the pelvis and thigh stations to improve spatial resolution. The calves were imaged using a novel time-resolved strategy, which combined iPAT with TREAT. TREAT is based on the TRICKS concept but uses a different k space trajectory and region sharing scheme (fig. 1). Using both of these in combination, the calves were imaged with frame times of 5 seconds per 3D set and voxel sizes of 1.2 x 0.7 x 1.2 mm^3.

For evaluation purposes, the time-resolved dynamic series was 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.

Static and Dynamic infrapopliteal images from each patient were assessed independently by two blinded readers, a radiologist and a vascular surgeon. Arteries were characterized as having either 1) significant stenosis (>50%), 2) segmental occlusion, 3) complete occlusion without reconstitution, 4) other vascular lesion, or 5) additional disease/incidental pathology. Static and dynamic images were compared.

Results:

Time-resolved MRA using TREAT and iPAT was successful in all cases and produced diagnostic image quality. Dynamic time-resolved MRA produced a change in diagnosis in 38% of infrapopliteal arteries, resulting in a change in diagnosis in 30% of patients. Change in diagnosis on time-resolved MRA was due to asymmetric flow, slow flow and reconstitution of distal runoff vessels on delayed frames. Incidental pathology (i.e. arthritis, cellulites), which may contribute to symptomatology, was identified on time-resolved MRA in 25% patients.

Discussion:

Time resolved CEMRA using GRAPPA and TREAT is a novel technique that can produce detailed images of the infrapopliteal arteries with temporal resolution of 5 seconds per frame. Reconstitution of distal runoff vessels can be visualized with time-resolved imaging thus identifying a target vessel for surgery, which may result in significant changes in clinical management.

[1] Carr JC, et al. ISMRM 2002
[2] Morasch M, et al. J Vasc Surg 2003; 37: 62-71
[3] Carr et al. International MR Angio Club, London, Ontario, September 2004

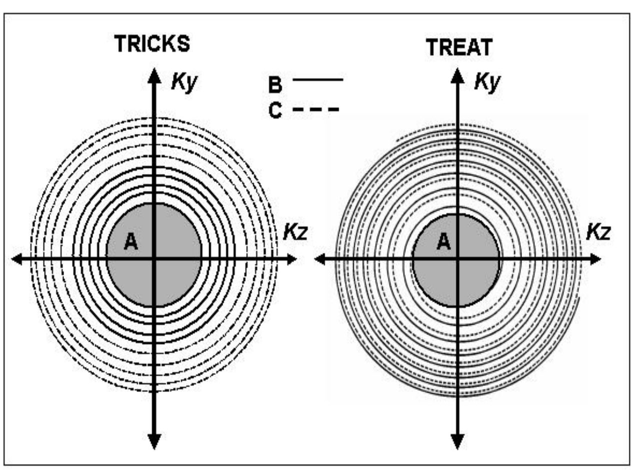

Figure 1: A comparison of the k-space segmentation schemes of a 3-region (A, B and C regions) TRICKS and TREAT pulse sequences. (a) An elliptically centric encoded TRICKS acquisition acquires A, B, and C regions concentrically with the A region covering the central 1/3 of k-space (solid gray region), the second 1/3 is the B-region (solid lines) and peripheral 1/3 the C-region (dashed lines). (b) The TREAT sequence defines the A-region the same as TRICKS, but interleaved the B-(solid lines) and C-regions (dashed lines).

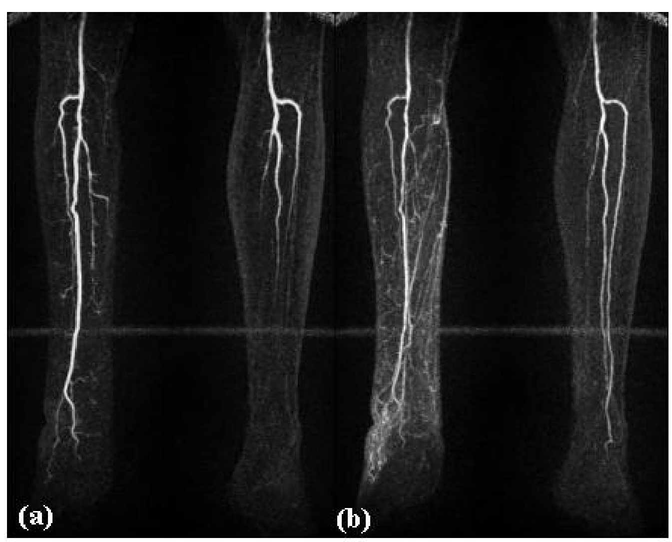

Fig 2 (a) represents an early frame from the time-resolved series and shows delayed filling of runoff vessels on left. Fig 2 (b), at later time point, shows filling of left calf vessels.