4D-TRAK combines high speed and spatial resolution for vascular studies

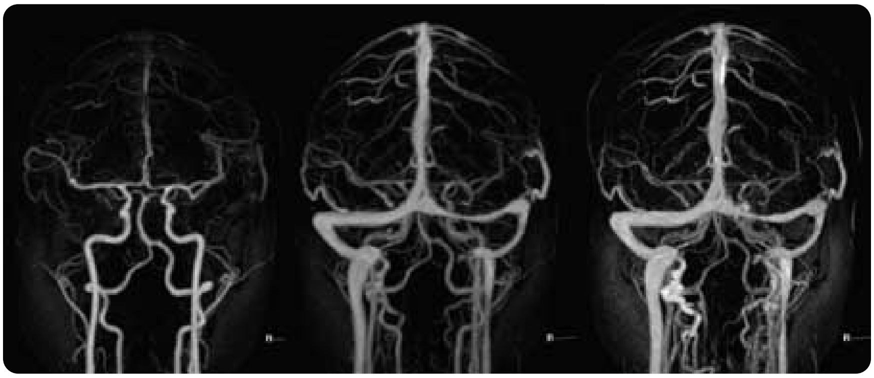
Münster radiologists combine SENSE and CENTRA keyhole methods to boost spatial and temporal resolution in MRA

Dr. Bernd Tombach

Imaging studies designed to help radiologists distinguish the degree of stenosis in cerebral vessels need to be both fast and capable of resolving details in the smallest vessels. Traditional MRA techniques can provide high speed and high resolution but not enough of both to reliably depict certain challenging cerebrovascular pathologies, says Bernd Tombach, M.D., radiologist at University Hospital Münster. Doctors at Münster have been using a prototype of Philips' 4D-TRAK technique for over two years in diverse vascular imaging applications, including their most recent clinical use in cerebrovascular studies. 4D-TRAK combines the speed of SENSE and CENTRA keyhole methods to deliver the all-important high spatial and temporal resolution to resolve cerebrovascular anatomy and pathology.

In 2003, radiologists at University Hospital Münster began using the 4D-TRAK technique to avoid venous overlay in the run-off (peripheral) vascular system. In a three-FOV study (i.e., aortoiliac system, femoral system, lower leg system), venous overlay often occurs due to disparate flow velocity and arterial filling times between right and left legs, a common observation in peripheral arterial occlusive disease (PAOD). Using conventional MRA exclusively for the run-off system could provide the speed to overcome venous contamination, but at the cost of unacceptably low spatial resolution.

"We adopted a hybrid approach that started with a 4D-TRAK study of the run-off system, consisting of eight dynamics of the lower leg vasculature in the coronal orientation and using a PV coil, followed by the bolus chase method for the aortoiliac and femoral system," Dr. Tombach says. "In the peripheral system, we typically obtained a voxel size of 1.22 mm in each direction, with a reconstructed voxel size of 0.88 x 0.88 x 0.61 mm. The total scan duration was 2:05 minutes, with 10.2 seconds for each dynamic 4D-TRAK acquisition. We simply look at the MIPs of each dynamic acquisition to determine which original data set to examine to enable the diagnosis."



4D-TRAK study of cerebral vasculature, done at 1.5T. Temporal resolution is 7 seconds.

Subsequently, Münster clinicians combined 4D-TRAK with whole body MRA in a preliminary unified approach for four FOVs. “This study used a bolus chase technique for the aortic arch with the carotid arteries, the aortoiliac region, the femoral arteries and the run-off system documenting the feasibility,” he says.

Versatile 4D-TRAK enhances cerebrovascular studies

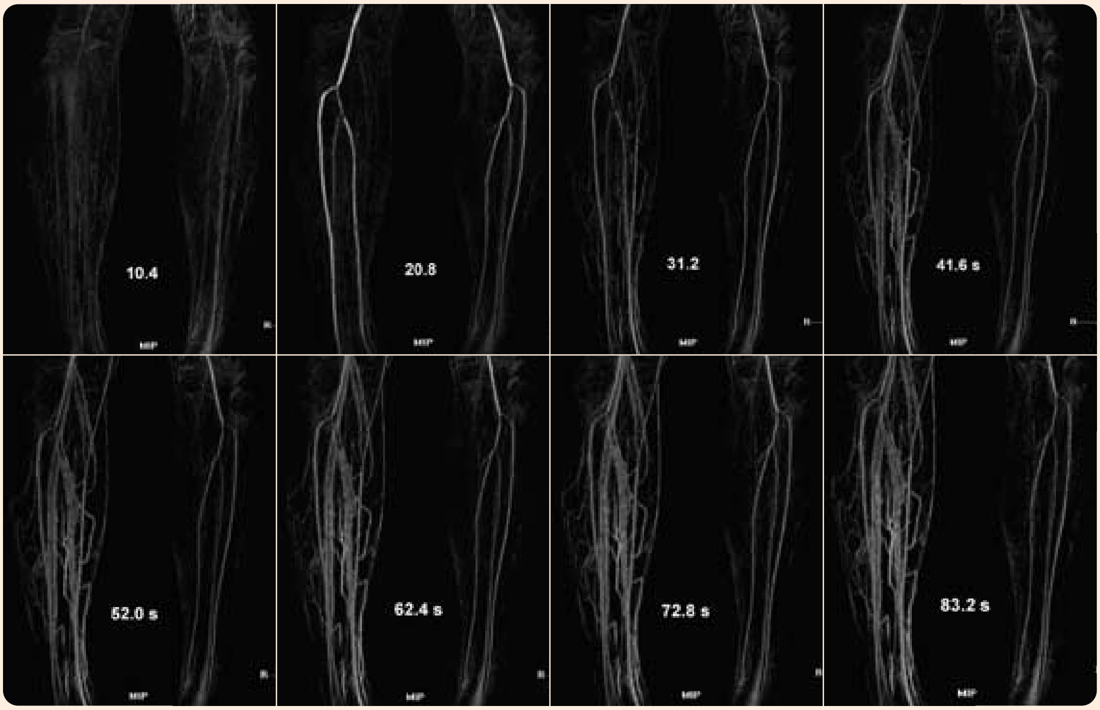
In 2005, Münster radiologists began applying 4D-TRAK to the cerebrovasculature. Cerebrovascular pathology may be either arterial or venous in nature, often making MRA technique selection difficult if presenting symptoms are ambiguous. “If you use a time-of-flight technique for the arterial system and a phase contrast technique for the venous system, it takes up to 10 minutes acquisition time to achieve an appropriate image quality,” Dr. Tombach observes.

“Since arteriovenous shunting time is just two to four seconds, regular CE-MRA – even with a short acquisition of, say, 15 seconds – isn’t fast enough to avoid venous overlay. We envisioned combining the two MRA techniques to image the arterial and venous systems in one rapid approach using a single contrast agent injection.”

Implementing 4D-TRAK on their 1.5T system, Münster radiologists are able to obtain a measured voxel size of 0.78 x 0.78 x 1.4 mm and a reconstruction voxel size of 0.39 x 0.39 x 0.7 mm, with a dynamic 4D-TRAK scan acquisition time of just 7.3 seconds per 3D volume and a total scan time of 1:03 minutes for all dynamics. On the center’s Intera 3.0T system, maintaining the same spatial resolution, clinicians can even further reduce the temporal resolution to 3.5 seconds.

Net Forum
www.philips.com/netforum

Visit the MRI NetForum Community to view more 4D-TRAK results contributed by Dr. Tombach.



1.5T 4D-TRAK peripheral MRA study demonstrating high spatial and temporal resolution.

Economizing on k-space scanning with 4D-TRAK

The 4D-TRAK technique is a synergistic combination of two fast acquisition methods, SENSE and CENTRA keyhole.

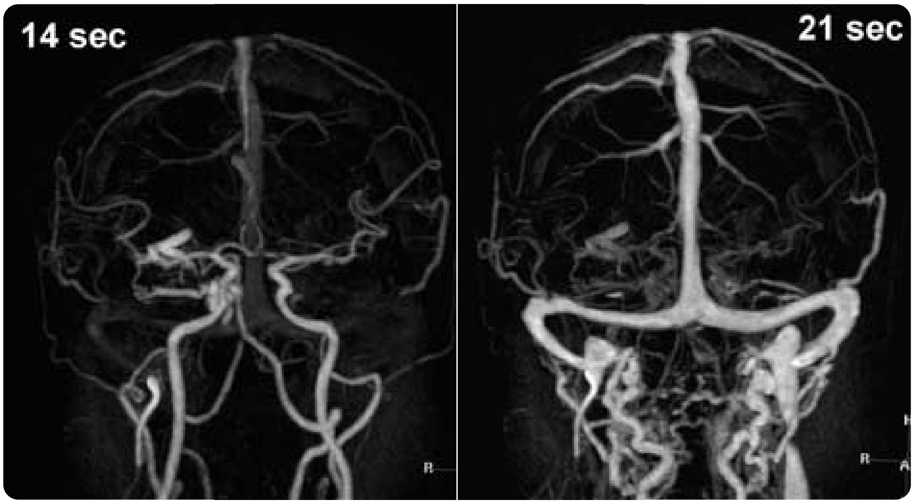
SENSE (sensitivity encoding) is Philips' well-known parallel imaging technique that employs multiple RF coils and receivers and a special algorithm to enable acquisition speed increases. The SENSE factor used generally equals the scan time reduction factor, its maximum value depending on the geometry of the RF receive coil.

CENTRA, Contrast-Enhanced Timing Robust Angiography, is a k-space sampling strategy that optimizes CE-MRA image acquisition during arterial contrast. CENTRA scans the central, contrast-determining cylinder of k-space first, during the initial few seconds of arterial contrast. Following the arterial phase, acquisition of the peripheral k-space parts can be conducted to obtain the structural, high-resolution information.

The CENTRA keyhole method varies the acquisition by updating a small central k-space cylinder (e.g., 16% of k-space) at various times during the scan. The efficiency of scanning a fraction of k-space, as though looking through a keyhole, results in an automatic six-fold acceleration of dynamic MRA.

The combination of SENSE's speed (e.g. 8x faster) and the speed of keyhole (e.g. 6x faster) and halfscan (1.25x faster) can lead to an incredible speed-up of, in this case, 60x for 4D CE-MRA studies.

"If you want to match DSA's ability to help distinguish the grade of stenosis then you have to be below one millimeter in voxel size and 4D-TRAK accomplishes this easily," Dr. Tombach says. "Furthermore, using MR and 4D-TRAK avoids several DSA disadvantages, including an arterial puncture, risk of dislodging a thrombus, contraindications regarding renal impairment and radiation dosages, and a longer time slot. For run-off studies, in fact, after 150 patient examinations we use 4D-TRAK exclusively instead of DSA. "Our clinical colleagues are impressed with this technique and with the image quality in run-off studies," he adds. "For intracranial studies, we are changing more minds everyday. Our neuroradiologist increasingly asks for this technique as a planning scan for percutaneous interventions, 4D-TRAK actually leads to a shorter interventional procedure."



Total volume MIP's of dynamics of a 4D-TRAK scan at 1.5T of a patient with a sinus cavernosus fistula.