New horizons for MRI of vascular calcifications

The presence of dense peripheral vascular calcifications has negative prognostic implications in patients with peripheral arterial disease (PAD). In addition, the presence of dense calcifications may alter the choice of access site for patients undergoing percutaneous revascularization or TAVR (transcatheter aortic valve replacement) procedures. Peripheral MR angiography is commonly used as an alternative to CT angiography for the evaluation of patients with PAD. While peripheral vascular calcifications are readily depicted with CT angiography, they are inapparent with MR angiography (MRA).

In this work, we present an approach that combines nonenhanced MRA with tailored 3D imaging of vascular calcifications. While QISS is used for nonenhanced MRA, we propose two options for imaging of vascular calcifications:

1. **PETRA**, which relies on the use of an ultra-short echo time.
2. **StarVIBE** – as part of FREEZEit – which acquires data using a stack-of-stars k-space trajectory. Briefly, we adjust the echo time such that fat and water signals are in-phase, and apply a very small flip angle for the RF excitation which minimizes the impact of T1 relaxation time differences among tissues. This approach generates a homogenous signal level across most tissues, except for calcifications appear dark due to a very short T2* relaxation time. The use of StarVIBE is also helpful in minimizing motion sensitivity in the abdominal and pelvic regions compared with a fully Cartesian 3D acquisition.

1 Requires QISS license on the scanner.

69-year-old male. MIP coronal QISS MRA (1A) demonstrates patent arterial lumen with excellent correlation to CTA (1B). MinIP coronal projections of PETRA (1C, B/W inverted) and StarVIBE (1D, B/W inverted) both demonstrate the calcifications seen on the CTA, but the calcifications are better defined using the latter technique.

54-year-old female. Axial reconstruction (B/W inverted) from StarVIBE (2A) demonstrates a ring of calcification in the left external iliac artery, which corresponds closely to the appearance on CTA (2B).
How to build your protocol on syngo.MR E11A 1.5T MAGNETOM Aera-XQ system?

1. PETRA approach:
   One can start with the default PETRA protocol that can be found in the following location:
   Default → Sequence Region → Siemens Seq → Default.
   The parameters to be updated are as follows:

2. StarVIBE approach (requires FREEZEit license):
   One can start with any of the StarVIBE sequences. We started with the one in following location:
   SIEMENS → abdomen → library → 3D
   The parameters to be updated are as follows:

Please make sure that fat-suppression and centric ordering are turned off.

Suggestions for 3T imaging

1. For PETRA: No change required.
2. For StarVIBE: Please use the above values from MAGNETOM Aera-XQ, and then change the following
   TE = 2.46 ms, Flip angle = 2.5°, TR = 4.8 ms.

Post-processing to generate CT-like images

Both MR sequences generate images that make calcifications appear dark. This can be changed by going to the 'Image' menu, choosing the 'Color Lookup Table' option, and then selecting 'Inverted Gray Scale'. Now the calcifications appear bright – just like in CT. Use of a minimum intensity projection (MinIP) can improve display of the vascular calcifications.

Discussion

We have shown that angiography and calcification imaging can be accomplished using nonenhanced MR approaches during a single scan session. We presented two approaches for imaging of vascular calcification, one based on PETRA and the other on StarVIBE. In our experience so far, the StarVIBE outperforms PETRA due to its insensitivity to motion and overall image sharpness. A more detailed analysis, including 3T results, can be found in our recently published article "MR Imaging of Iliofemoral Peripheral Vascular Calcifications using Proton Density-Weighted, In-Phase Three-Dimensional Stack-of-Stars Gradient Echo" by Edelman et al. in Magnetic Resonance in Medicine, 2016.

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PETRA
Sensitive to motion
Available on all syngo.MR E11 systems

StarVIBE
Insensitive to motion
Part of the FREEZEit option

Coils: Body matrix coils were used in our studies.