Magnetic Resonance Angiography (MRA) of the lower extremities with Parallel Imaging and a dedicated 36 Element Matrix-Coil at 3 Tesla

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Introduction: Today there are few methods of imaging the arterial vasculature of the lower extremity. Precondition for this kind of examination is a high spatial resolution as it is known from digital subtraction angiography (DSA) and a high reproducibility. Disadvantages of DSA and computer tomographic angiography (CTA) are the ionizing radiation as well as nephrotoxic contrast agents (CA) [1]. Magnetic resonance angiography (MRA) does not suffer from these drawbacks but has a reduced spatial resolution. The implementation of matrix-coils and parallel acquisition techniques (PAT) as well as higher field strength at 3 Tesla offer the possibility of high spatial resolution angiography without ionizing radiation and nephrotoxic CA and a high reproducibility [2]. Aim of the presented work was to evaluate the advantages of a dedicated peripheral angio array coil in terms of SNR gain, increasing spatial resolution while shortening acquisition time.

Material & Methods: We examined four healthy male volunteers (30±4) with a prototype of a 36 element dedicated peripheral angio array coil (**figure 1**) on a 3T 32 channel MR System (Trio, Siemens Medical Solutions, Erlangen, Germany). The elements in this coil are organized in 6 levels along the patient axis (z-direction). Each level consists of two clusters, one for each leg. Each cluster consists of 3 coil elements. A total of 24 PA Matrix coil elements, or a total of 4 levels in z-direction, are sufficient to cover a FoV of 50cm. To cover the complete lower part of the body in addition to the angio arry two body array coils were used to cover abdomen and proximal thigh. The MRA imaging protocol was taken from an existing MRA protocol which used two body-matrix coils to cover the abdomen and proximal parts of the thigh and no dedicated coil but the body coil for the lower leg. The protocol was optimized for the dedicated peripheral angio array coil in terms of increasing spatial resolution, reducing acquisition time while keeping SNR as high as possible. A 3 step MRA of the lower body-part from the diaphragm down to the feet was performed with a PAT acceleration factor of 3 and a spatial resolution of less than $1.4x1.1x1.2mm^3$ in all steps (**table 1**). A standard CA (0.5 mloar) was administered with a power injector (Medrad Spectris, Medrad Inc., Indianola, USA) with a bolus divided into 10ml CA at a flow rate of 1.5ml/s followed by 10ml CA at a flow rate of 0.8ml/s. After CA injection a 30ml saline flush was administered at the same flow rate of 0.8ml/s. Signal to noise ratio (SNR) measurements were performed before and after administration of CA. Due to the inhomogeneous distribution of noise when applying PAT, noise can not be measured but has to be calculated. This was done with the recently described difference method [3]. The pre-contrast images were acquired twice in each stage and then subtracted from each other. The standard deviation of signal in a defined region of interest (ROI) in these subtracted images was taken as noise. After CA administration signal was measured in the same ROI. To differentiate between signal increase in the vessel lumen from increase in soft tissue, ROIs were placed in the popliteal artery as well as next to the vessel in muscle tissue. To evaluate SNR increase compared to peripheral MRA performed without a dedicated coil, datasets from exams performed with the body coil were evaluated as well.

Results: MRA of the lower body-part could be performed without any venous overlay. Acquisition time could be reduced to a total of 54 seconds while applying PAT with an acceleration factor of 3 in all steps (**figure 2**). Integration of a new designed 36 element peripheral angio array coil into an existing MRA protocol was trouble free. Mean SNR in the MRA examinations was 11.47 ± 3.2 pre-CA administration, after CA injection it increased to 95.35 ± 0.9 in the vessel lumen, in surrounding soft tissue it increased to 28.57 after CA injection.

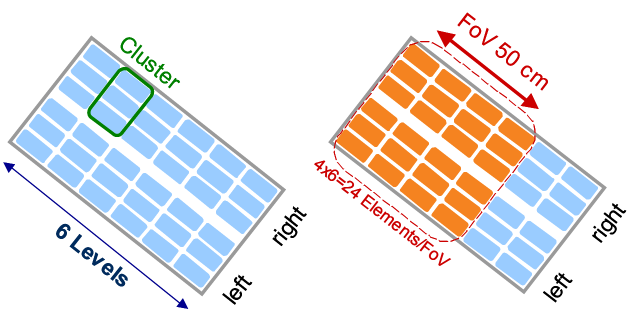

Figure 1: The PA Matrix consists of 36 elements, organized in 6 levels with 2 clusters per level. A total of 24 PA Matrix coil elements, or a total of 4 levels in z, are sufficient to cover a FoV of 50cm.

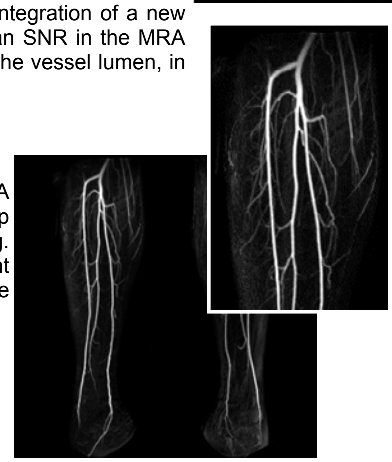

Figure 2: Composed MRA images and single step image of the lower leg. Note the excellent depiction of muscle branches.

	abdomen/pelvis	thigh	lower leg
acq. time	00:18	00:15	00:21
PAT factor	3	3	3
resolution	1.4x1.1x1.2	1.1x1.1x1.1	1.0x1.0x1.0
flip angle	19°	30°	30°
Matrix	448	448	512

Table 1: Sequence parameters of MRA performed with a dedicated peripheral angio array coil.

Conclusion: Implementation of a dedicated coil for peripheral MRA helps to increase image quality in terms of spatial resolution and SNR. Acquisition time can be further decreased because of higher PAT acceleration factors. The combination of a dedicated angio coil with other matrix coils is feasible. Venous overlay can be effectively avoided despite the use of high resolution scans. Excellent depiction of even small vessels from the abdomen down to the foot may lead to replacement of preoperative DSA by MRA.

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2. Leiner, T., et al., *Contrast-enhanced peripheral MR angiography at 3.0 Tesla: initial experience with a whole-body scanner in healthy volunteers.* J Magn Reson Imaging, 2003. 17(5): p. 609-14.
3. Reeder, S.B., et al., *Practical approaches to the evaluation of signal-to-noise ratio performance with parallel imaging: application*