Time Resolved Echo-shared Angiography Techniques (TREAT) with dedicated peripheral angiography Matrix-Coils and high acceleration factors at 3T: initial experience

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Introduction: High spatial resolution MRA has gained more and more credit in imaging the arterial vasculature from head down to the feet. Different MRA techniques are used for different organ systems and different questions, e.g. time-of-flight angiography for the intracranial vessels, contrast enhanced MRA for abdominal and peripheral vessels and phase contrast measurements for flow estimation. Spatial resolution of MRA and CTA is continually increasing but still digital subtraction angiography (DSA) has one unbeatable advantage. DSA offers dynamic information at a very high level. Temporal resolution of all other methods ranged around 5 seconds which is insufficient as diagnostic information. A very promising technique is time resolved MRA with view-sharing in combination with parallel acquisition techniques (PAT) [1, 2]. The aim of this work was to evaluate how much temporal resolution can be increased by applying higher acceleration factors without limiting diagnostic image quality.

Material & Methods: We used a TREAT (time resolved echo-shared angiography technique) sequence which combines view-sharing techniques and PAT. The principle of view sharing belongs in a higher read-out rate of the central k-space than the periphery of k-space. If k-space is dividet into three parts, conventional read-out runs A-B-C-A-B-C etc. When using view-sharing it runs A-B-C-A-B-A-C-A-B etc (**figure 1**). As a receiver coil we used a prototype of a 36 element peripheral angio array coil on a 3 Tesla MR System (Trio, Siemens Medical Solutions, Erlangen, Germany). The arrangement of 36 elements in the coil allows to increase PAT acceleration factors up to four. We compared results from an earlier study which used an acceleration factor of two with new measurements when applying PAT three and four. Spatial resolution in these measurements was $1.4x1.4x1.5mm^3$, flip angle 16°, 256x256 matrix size and 360mm filed of view. Acquisition time was 1:14 minutes when using an acceleration factor of three, 1:01 minutes at a factor of four which results in a temporal resolution of 3.7 seconds/frame at PAT 3 and 2.9 seconds /frame at PAT 4. To evaluate image quality and diagnostic significance signal to noise ratio (SNR) measurements were performed and the area under the curve (AUC) of the arterial signal calculated. As a good diagnostic window more than 50% of the arterial signal were settled. A problem of SNR measurements when allying PAT is, that it is impossible to measure noise in the images because of it's inhomogeneous distribution. To solve this problem noise can be calculated by the recently described difference-method [3]. For contrast agent (CA) application a fixed injection scheme was used which consist of 8ml of CA injected at a flow-rate of 0.8ml/s followed by a saline flush of 30ml at the same flow-rate of 0.8ml/s. A fixed delay of 25 seconds was used to start the measurement which was calculated through the length of the extra corporal CA tube and the average height of the volunteers.

Results: Both acceleration factors (PAT 3&4) showed good diagnostic image quality. Timing was sufficient, in none of the measurements arterial or venous CA filling occurred in the first images of the time resolved acquisition (**figure 2**). Maximal arterial SNR reached 336.6 at PAT 3 and 214.34 at PAT 4. The AUC of more than 50% of the arterial signal had a size of 1425.44 at PAT 3 and 1100.63 at PAT 4. The measurement time was not long enough to see an arterial rerun-peak.

Conclusion: The implementation of time resolved techniques helped to overcome one of the last existing drawbacks of MRA. The combination of high filed strength, parallel acquisition techniques and dedicated angiography coils make it possible to perform MRA at both good spatial and temporal resolution. Certainly the temporal resolution of DSA is not yet reached but dynamic information with a resolution of less than 3 seconds / image gives a huge gain on diagnostic information compared to static Angiography, e.g. in the differentiation of a high grade stenosis or pseudo occlusion compared to a complete occlusion and retrograde filling

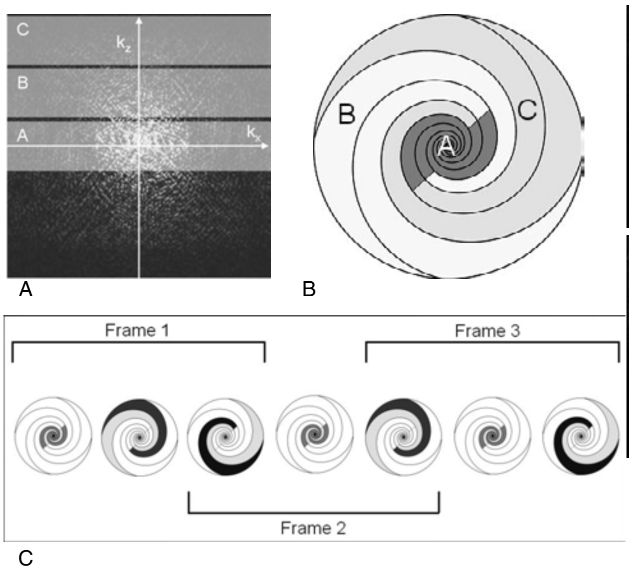

Figure 1: Comparison of k-space read-out methods. A) conventional k-space read-out, B) k-space read-out when applying view-sharing, C) composition of different k-space parts to a complete frame.

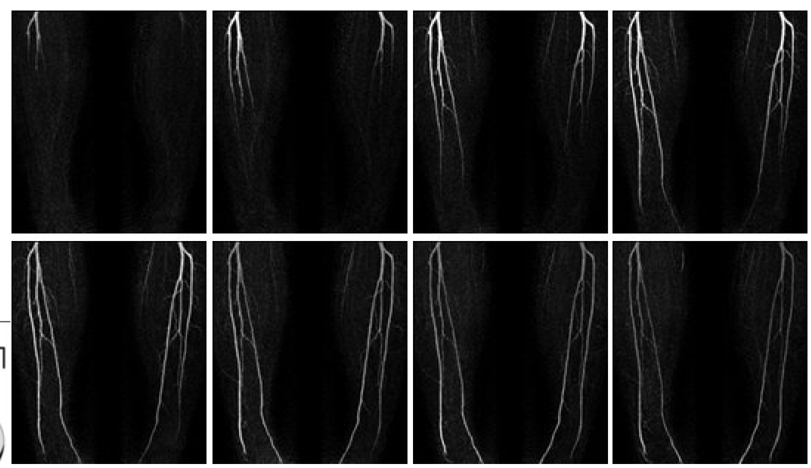

Figure 2: Dynamic MRA of the lower extremity at a PAT acceleration factor of 3 with a temporal resolution of 3.7 seconds / frame.

1. Du, J., et al., *SNR improvement for multiinjection time-resolved high-resolution CE-MRA of the peripheral vasculature.* Magn Reson Med, 2003. 49(5): p. 909-17.
2. Fink, C., et al., *Time-resolved contrast-enhanced three-dimensional magnetic resonance angiography of the chest: combination of parallel imaging with view sharing (TREAT).* Invest Radiol, 2005. 40(1): p. 40-8.
3. Reeder, S.B., et al., *Practical approaches to the evaluation of signal-to-noise ratio performance with parallel imaging: application with cardiac imaging and a 32-channel cardiac coil.* Magn Reson Med, 2005. 54(3): p. 748-54.