GRAPPA with a TWIST: Dynamic 4D CE MRA of the cerebral vasculature at near isotropic resolution

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Introduction: MR angiography of the brain has increasingly been used to evaluate patients with suspected pathology of the cerebral vasculature. However, most clinically standard MRA sequences only allow interpretation of either the arterial or the venous phase. In comparison to DSA, the dynamic information of a passing contrast bolus is lacking since conventional time-of-flight or CE MRA currently do not provide the necessary temporal multiphase information. In order to gain the required temporal resolution for dynamic imaging, we sought to determine if the combination of the parallel imaging method GRAPPA with the K-space method TWIST would provide sufficient dynamic information in a study comparing the new fast contrast enhanced MR angiography sequence to a conventional time of flight MRA in the evaluation of patients with previously known neurological disorders.

Methods: All examinations were performed under institutional review board approved protocols. 25 consecutive patients, undergoing contrast enhanced MRI of the head for exclusion or follow up of brain pathology were included into this prospective study. Patients were examined on a 1.5 T Magnetom Espree (Siemens, Erlangen, Germany) equipped with a standard 12-channel head coil. In addition to the standard head examination, a non-CE time-of-flight MRA (TR/TE= 41 ms/7 ms; matrix 320x240; flip angle 20°; GRAPPA acceleration factor = 2; TA 5:28 min) and a four-fold GRAPPA accelerated dynamic contrast enhanced TWIST-MRA[1,2] (TR/TE= 3.28 ms/ 1.51 ms; matrix 256 x 176 x 64; flip angle 25°; TA 40 sec) were acquired. The latter allowed the acquisition of 8 different phases during one contrast bolus injection at near isotropic resolution (0.98 x 0.98 x 1.5 mm). Contrast enhancement was achieved using a single bolus injection of 0.2 mmol/kg body weight gadoversetamide (Optimark, Mallinckrodt Inc., St. Louis, MO). There was no need for a test bolus injection. Single rater interpretation was performed with regard to vessel identification at the circle of Willis on a single best image basis, identification of small caliber vessels (A2, M2/3, and P2 segments) on all information available, and over all image quality.

Results: All patients tolerated the examination well. The biggest advantage of the TWIST MRA derived from the dynamic image information. The sequence provided high resolution images allowing the differentiation of multiple arterial, parenchymal and venous phases. Due to this, particularly in the late arterial phase, vessel depiction of small caliber arteries was superior in all 25 patients to the non-dynamic TOF MRA. However on a single best image, TOF MRA provided superior image quality and vessel visualization of the vasculature of the circle of Willis and proximal MCA, ACA and PCA branches arising from it in 23/25 patients. In 2/25 patients TWIST MRA provided an overall better depiction than the TOF MRA. In a patient with a vessel clip, TOF MRA did not allow visualization of a 3.7 x 2.4 x 3.5 cm^3 volume, whereas TWIST MRA provided excellent vessel visualization (Fig.2). Also, patient motion had a strong negative impact on TOF MRA image quality preventing image analysis in one patient. However, the accelerated TWIST MRA delivered high quality dynamic MRA with superior vessel differentiation in this patient despite that motion. Finally, TWIST MRA in all patients enabled analysis of the venous drainage, which is not available in a conventional TOF MRA.

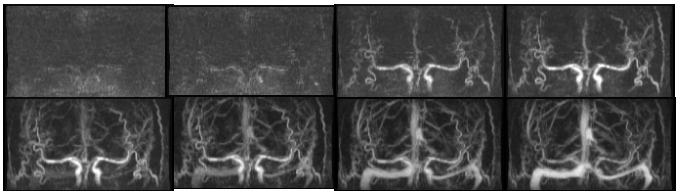

Fig. 1. Coronal view of eight phases of a contrast enhanced GRAPPA accelerated TWIST MRA showing arterial inflow, parenchymal phase and venous drainage obtained in 40 sec. Images may also be viewed in the sagital and axial plane.

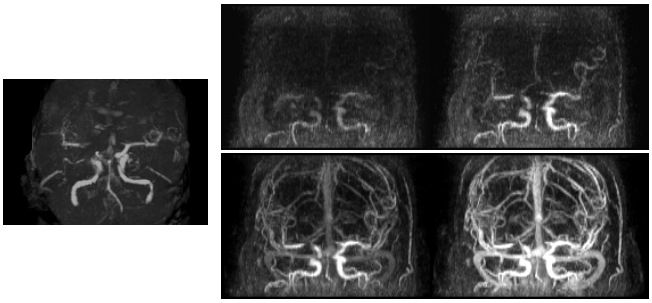

Fig. 2. Left, Maximum intensity projection (MIP) of a TOF MRA (coronal view). Due to a vascular clip image interpretation is impacted precluding visualization of the carotid genu, the proximal M1 segment of the MCA and the entire ACA on the right and most of the contra lateral A1 segment. Right, TWIST MRA allows image interpretation of the ICA and both ACA. Only at the specific site of the vessel clip does missing signal preclude vessel visibility.

Conclusion: Dynamic 4D accelerated MR angiography using GRAPPA with a TWIST sequence allows, for the first time, examination of the entire vasculature of the brain throughout the dynamics of bolus passage. The extremely rapid acquisition delivers results previously unavailable particularly in patients prone to motion and those with metal artifacts. The current results were acquired utilizing a 4-fold GRAPPA acceleration in only the right-left dimension: adding additional acceleration in the cranio-caudal dimension will permit further enhancement. The simplicity of data acquisition makes the method clinically attractive, as bolus timing is unnecessary. As all phases of anatomy from artery through veins are readily displayed. GRAPPA MRA with a TWIST can strongly impact imaging of patient cerebral vasculature in day to day practice.

Ref: 1 G. Laub et al. *MR Angioclub Basel*; 2006 2 M. Blaimer et al. ISMRM 2007, #749

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