Noncontrast enhanced MRA with compressed sensing and parallel imaging for evaluation of branches of the aortic arch

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Target audience: Physicians, technologists and scientists who are interested in non-contrast enhanced MR angiography applying to the area of branches of the aortic arch including carotid bifurcation to detect cerebrovascular diseases.

Introduction: Non-contrast enhanced MR Angiography (NC-MRA) using an investigational version of Inflow Inversion Recovery technique with 3D FSE (IFIR FSE: GEHC) can be used for evaluation of arteries in the neck (Fig1)[1]. MRA at 3T may now provide stable image quality with high signal intensity (SI). To facilitate acceleration of imaging, compressed sensing (CS) can be combined with fast imaging technique with parallel imaging ARC (GEHC) without apparent loss of SI[2)]. However, acceleration of fast imaging is dependent on degrees of efficient reduction of k space data, and optimization of k space sampling might be essential. The purpose was to evaluate feasibility of NC-MRA at 3T in combined use of CS and parallel imaging ARC for the evaluation of the neck arteries as a screening method.

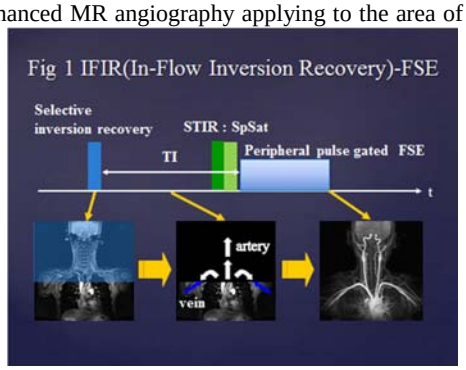
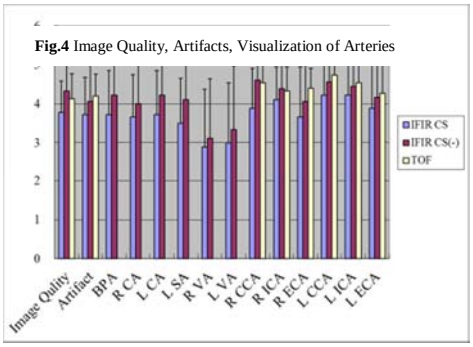


Fig.1 NC-MRA IFIR – FSE pulse sequence.

Materials and Methods: The current study was approved by the institutional review board and informed consent was obtained from all the involved subjects. All MR images were obtained on a 3T magnet (Discovery MR750, GEHC) with head and neck phased array coil. ***[Preliminary study]*** In a pilot study, peripheral pulse gated (PG) NC-MRA with IFIR FSE was performed in normal volunteers in a coronal plane covering the aortic arch to the skull base. Several parameters were examined including matrix size of 256x256 to 320x320, ARC factor of 3x1-3x2, 4x1 with and without CS factor of 2. We tentatively fixed parameters from normal volunteers, and performed PG NC-MRA with IFIR FSE with and without CS in 13 patients who had a suspicion of cerebrovascular diseases with the following parameters, TR/TE 4000ms~/3.7ms, FOV30cm, matrix 256x256, ARC 3x1. Image quality was evaluated. ***[Clinical study]*** After fixing the parameters for imaging in light of the preliminary patients' data, we have studies 20 patients (16 men, 4 women, mean age 70.7years ranged from 35 years to 81years), who had possible cerebral vascular diseases with IFIR FSE MRA with and without CS factor of 2 using a matrix of 320x320. For the evaluation of the carotid bifurcation, 3D time of flight (TOF) was obtained for comparison with the parameters of TR/TE 18ms/3/4ms, FOV 16cm, matrix 320x192, slice thick 2mm, overlap 1mm, number of images 72, and imaging time 2,22 without PG. *Data analysis;* Image quality, artifacts and visualization of origins of branches of the aortic arch (brachial cephalic arteries (BCA), common carotid (CCA), subclavian (SA), vertebral (VA) were ranked with a 5-point scale (1 bad-5 excellent) in IFRIR FSE MRAs with and without CS. And visualization of the distal CCA, proximal internal and external carotid (ICA, ECA) around the carotid bifurcation was also evaluated with a 5-poin scale in IFRI FSE and TOF MRAs.

Fig.4 Image Quality, Artifacts, Visualization of Arteries



Results: ***[Preliminary study]*** In a pilot study of normal volunteers, with an increase of ARC factor from 3x1, 3x2 to 4x1, overall SI of MRA decreased. With CS factor of 2, image quality tended to be preserved whereas that using equivalent reduction of imaging time with solely applied ARC degraded. In normal volunteers in combined use of CS factor of 2, acceptable image quality was obtained with ARC 3x1, a matrix of 256x256, and slice thickness 1.4mm. However, in MRA in the patients with these parameters, the image quality tended to be degraded (Fig2). ***[Clinical study]*** With a matrix of 320x320, image quality tended to be preserved with CS (Fig3). The imaging time was approximately half in NC-MRA with CS in comparison with that without CS (imaging time 3.7min vs. 2min with CS). Imaging time was dependent on heart rate of each patient. In two patients with arrhythmia and one patient with heart rate higher than 90 bpm of 20 patients, image quality of MRA with IFIR FSE was inferior to that using that with TOF and NC-MRA with TOF might have stable image quality (Fig4). In the patients with stable heart rate, the image quality and visualization of the arteries were acceptable (Fig3). In some patients, the visualizations of the arteries in NC-MRA with IFIR FSE using CS were inferior to those with NC-MRA with IFIR FSE without CS (Fig4).

Discussion: The current study demonstrated the feasibility of NC-MRA with IFIR FSE in combination of parallel imaging ARC and CS for the evaluation of the branches of the aortic arch. For the evaluation of patients with cerebral vascular diseases, robust image quality of NC-MRA with optimized parameters should be preserved. Further improvement of image quality and higher acceleration of imaging can be expected with sophisticated k space view ordering and filling combined with CS and parallel imaging.

Conclusion: NC-MRA with IFIR FSE using PG at 3T with CS and ARC may provide acceptable image quality for the evaluation of the arteries from the aortic arch to the skull base in a short imaging time and can be used as a screening method without contrast medium.

Reference 1) Takei N, Miyoshi M, Kabasawa H. J.Magn.Reson.Imaging 2012;35:957-962 2)King KF. ISMRM 2008 1488.

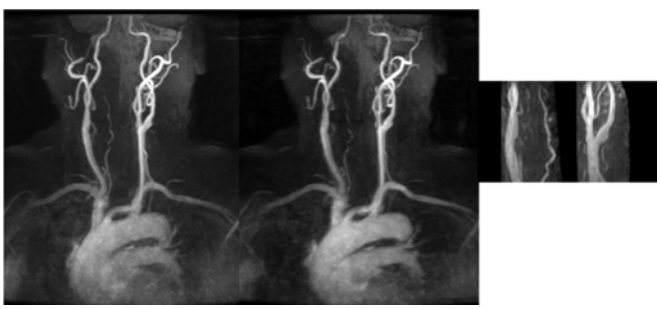


Fig.2 Preliminary results show coronal MIP images with 256x256 . left: IFIR FSE CS (+), middle: IFIR FSE CS(-), right: 3D TOF.

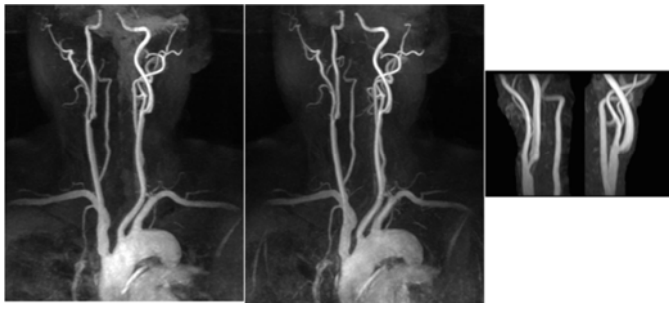


Fig.3 Clinical study show coronal MIP images with 320x320. left: IFIR FSE CS (+), middle: IFIR FSE CS(-), right: 3D TOF.