Non Contrast 3D Volumetric Time-Resolved MRA combining Multiple Phase FAIR(CINEMA-FAIR)

M. Nakamura[1], M. Yoneyama[1], T. Okuaki[1], T. Tabuchi[1], A. Takemura[2], M. Obara[2], J. Ogura[1], and S. Tsutsumi[3]
[1]Medical Satellite Yaesu Clinic, Chiyoda-ku, Tokyo, Japan, [2]Philips Electronics Japan, Tokyo, Japan, [3]Neurosurgery, Juntendo University Urayasu Hospital, Chiba, Japan

Introduction

Detailed information on anatomy and hemodynamics in cerebrovascular disorders such as AVM and Moyamoya disease is mandatory for defined diagnosis and treatment planning [1]. DSA may still be a gold standard for diagnostic modality but is otherwise invasive. Contrast-enhanced dynamic MR angiography (CE-dMRA) is a useful technique but poses a risk associated with contrast agent [2]. Currently most widely used non-contrast MRA techniques are TOF and PC. Also arterial spin labeling (ASL) technique has come to be applied to MRA and perfusion imaging in recent years[3, 4]. Those non-contrast techniques are, however, mostly limited to a single frame images. Recently we have proposed 3D volumetric non-contrast time-resolved MRA technique termed Contrast inherent inflow enhanced multi phase angiography combining multiple phases FAIR (CINEMA-FAIR). CINEMA was developed as a technique that enables diachronic observation of hemodynamics as in CE-dMRA and extensive 3D volume acquisition with the whole brain as a target. We present a preliminary study of CINEMA sequence and discuss its clinical relevance.

Methods

Theory and Pulse Sequence: CINEMA-FAIR technique combines ASL with 3D segmented T1 weighted gradient echo sequence (3D T1 TFE). FAIR preparation scheme with the Look-Locker sampling was used for spin tagging in this study (Fig 1)[5, 6]. Each measurement of the sequence was composed of two acquisitions with identical readout and different magnetization preparation schemes. Measurement was taken by two consecutive acquisitions preceded by nonselective and spatially selective inversion pulses, respectively. Upon completion of two acquisitions, corresponding temporal phases of two acquisitions with identical inversion delay are subtracted. The signal was then continuously acquired by a Look-Locker sequence with 3D T1 TFE readout.

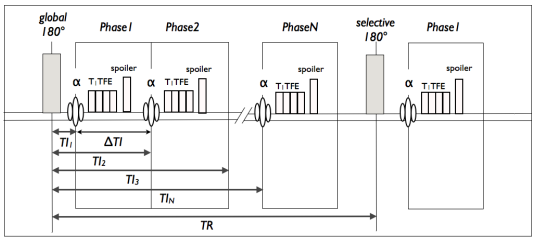

Fig 1 .Timing scheme of the CINEMA-FAIR sequence. After an initial global or slice selective 180° inversion pulse a series of T1-TFE images is acquired. Each of these image readouts is preceded by a low flip-angle excitation, which drives the longitudinal magnetization into a dynamic steady state.

CINEMA-FAIR was implemented with the following parameters: FOV=220×200mm2, Matrix=224×162, 3D acquisition with 100 × 1mm slices, resolution =1×1×1mm3, flip angle=10°, TR=4.5ms, TE=2.2ms, SENSE factor=3.0, TI/ΔTI/final TI=80ms/100ms/2.0s, number of acquired time points = 19. The scan Fig 1. Timing scheme of the CINEMA-FAIR sequence. After an initial global or slice selective 180° inversion time was approximately 7min. In-vivo experiments were performed in 10 healthy 3D TOF MRA was performed for anatomical comparison on all subjects with the following sequence parameters: FOV=220×200mm2, Matrix=224×162, 3D acquisition with 100 × 1mm slices, resolution =1×1×1mm3, flip angle=10°, TR=4.5ms, TE=2.2ms, SENSE factor=2.0. The study was approved by local-IRB, cons isted of 10 healthy volunteers and 2 patients. All experiments were performed on a Philips Achieva 3.0 Tesla scanner with Nova Dual gradients and software release 2.6 was used together with an 8 elements head coil. The alteration in longitudinal magnetization of stationary tissues and moving tissues (blood stream in this study) was converted into numbers by simulation. The signal strength of stationary tissues and blood stream were measured from images obtained from volunteer subjects and compared with the simulation models. The image quality of CINEMA-FAIR was compared with that of TOF MRA in terms of the depiction of the detailed anatomy.

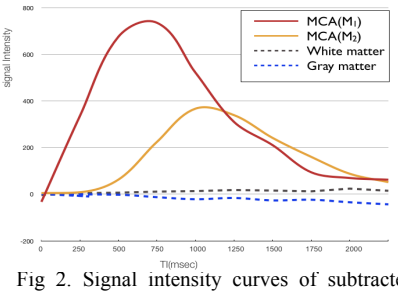

Fig 2. Signal intensity curves of subtracted images from volunteer studies

Results

Major intracranial blood vessels were extracted successfully in all volunteer studies. Longitudinal magnetization and signal intensity of CINEMA-FAIR images from volunteer studies were identical to the simulation result (Figure 2). CINEMA-FAIR could extract the blood flow in the whole brain at an interval of 100 ms and thus permitted us to observe vascular construction in full by preparing MIP images of axial, coronal, and sagittal acquisitions with 1 mm × 1 mm × 1 mm spatial resolution. In MIP images TOF and CINEMA sequence, the quality of appearing the main blood vessels and their branches was identical, while CINEMA sequence provided additional hemodynamic information (Fig 3).

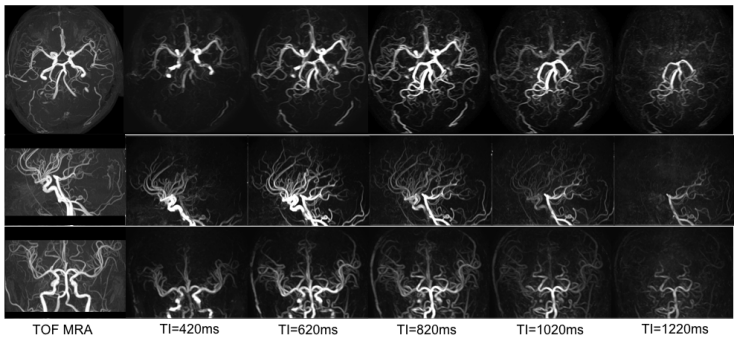

Fig 3. CINEMA-FAIR and TOF images acquired from a healthy volunteer. MIP images acquired at representative phases form one subject with a 200ms temporal resolution and 1×1×1mm3 spatial resolution.

Conclusion

This preliminary study demonstrated the usefulness of CINEMA-FAIR technique in evaluating the cerebral vasculature. High quality both in temporal and spatial resolutions was simultaneously achieved, obviating the need for contrast agent. Patients carrying cerebrovascular abnormalities such as AVM and Moyamoya disease are subjects of further investigations (Fig 4).

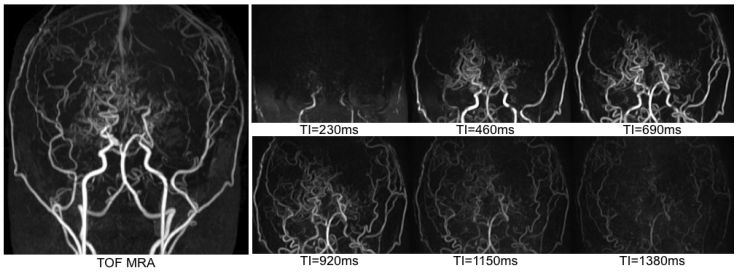

Fig. 4. CINEMA-FAIR and TOF images in Moyamoya disease.

References
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