Whole-body DWI: reduction of scan time using direct coronal acquisition

Hayato Takano[1], Tomohiko Horie[1], Isao Muro[1], Nao Kajihara[1], Yutaka Imai[1], Makoto Obara[2], Tetsuo Ogino[2], Akira Suwa[2], Marc van Cauteren[2], Gwenael Herigault[2], Thomas Kwee[3], and Taro Takahara[4]

[1]Radiology, Tokai University School of Medicine, Isehara, Kanagawa, Japan, [2]Philips Healthcare, [3]University Medical Center Utrecht, [4]Tokai University School of Engineering, Hiratsuka, Kanagawa, Japan

INTRODUCTION Diffusion-weighted imaging (DWI) provides functional information and can be used for the detection and characterization of pathologic processes, including malignant tumors. Whole-body DWI has emerged in 2004 [1], and has gained interest for several oncological applications [2]. Nevertheless, it has not been used routinely so far due to its considerable scan time reaching 30 – 40 minutes (i.e., more than 1 hour for a comprehensive examination including conventional T1 or T2-weighted imaging). Another potential issue is severe distortion, especially seen at high-field (3.0T) platforms [3]. Although a direct coronal acquisition (instead of the usual axial acquisition) may reduce scan time thanks to the possibility to acquire less slices (keeping in mind body thickness), this approach was not practically executable due to non-negligible distortion. Thus, axial acquisitions keep on being employed for DWI, resulting in long scan times. In this work, we demonstrate the feasibility of reducing scan time in whole body DWI with a direct coronal acquisition at a 3.0T system, using a new digital coil architecture.

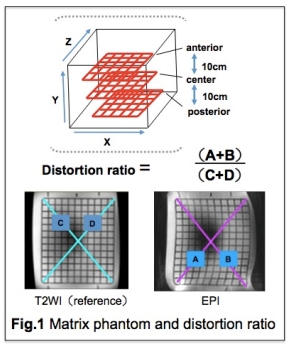

Fig.1 Matrix phantom and distortion ratio

MATERIALS AND METHODS

Phantom Study: To evaluate the potential advantages of the new system, we compared the degree of distortion and g-factor at two different systems with and without digital coil architecture (Achieva 3.0T TX, and Ingenia 3.0T, Philips Healthcare) in a phantom study.

(1) Comparison of distortion: A dedicated phantom with plastic matrix inside surrounded by Gd-based dilution fixed by macromolecule polymer was prepared (Fig.1). This matrix was scanned in the coronal plane with SE-T2WI (as a reference) and single-shot EPI with different echo train lengths from 23 to 94, and then calculated distortion ratio.

(2) Comparison of g-factor: A mineral-oil filled phantom was scanned with a T1-FFE sequence (TR/TE/FA: 200/4.6/80) in the coronal plane with changing reduction (SENSE) factor from 1 to 6. g-factor was calculated afterwards.

Table 1. Scan parameters

Acqisition plane	Coronal	Axial
Packages	2	4
Scan time	**2min32s**	**7min53s**
FOV (mm)	330 x 396	330 x 396
TR/TE/TI (ms)	6976/68/250	6976/68/250
Matrix	112x176	112x176
Reduction factor	5	5
THK/gap (mm)	3/0	3/0
Number of slices	60	110
NSA	1	1
b-factor (s/mm2)	1000	1000

Volunteer and Patient Study: The study was approved by local IRB and written informed consent was obtained from all subjects. A Total of 10 volunteers underwent MRI including two types of DWI with axial-based and coronal-based scanning. The scan parameters are shown in Table 1. In the volunteers, relative signal ratio of the spinal cord and the spleen compared to muscles (as a (homogeneously low signal intensity) reference standard) were calculated. Statistical significance was judged by a paired samples t-test (MedCalc ver.11.4.4). A *p*-value of 0.05 or less was considered significant. Then, eight patients with systemic tumors underwent whole-body DWI with a coronal acquisition. Distortion at DWI was visually compared to that at T2WI.

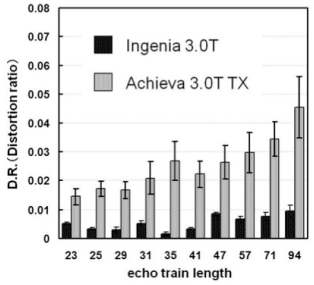

Fig.2 Comparison of distortion ratio. Ingenia 3.0T showed much smaller distortion.

RESULTS In the phantom study, the new 3.0T system with digital coil architecture showed considerably less distortion (Fig.2), and better g-factor especially at high reduction factor (Fig.3). In the volunteer study, it showed significantly higher relative signal ratio at coronally acquired DWI compared to the conventional system (Fig.4). In the patient study, distortions were quite small and reformatted images of diagnostic quality were successfully obtained(Fig.5).

CONCLUSION Whole-body DWI with direct coronal acquisition is possible at a 3.0T system with short acquisition time (2 min 32 sec for one station). This should increase the clinical attractiveness/availability of whole-body DWI for tumor evaluation.

References: [1] Takahara T, et al. Radiat Med 22(4); 275-82 (2004). [2] Kwee TC, Takahara T, et al. J Nucl Med 51(10); 1549-58 (2010). [3] Mürtz P, et al. Eur Radiol 17(12); 3031-7 (2008)

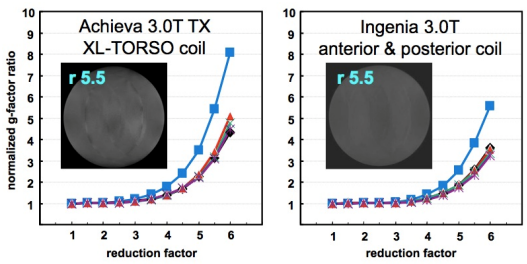

Fig.3 Comparison of g-factor. Ingenia showed better (smaller) g-factor especially at high reduction factor.

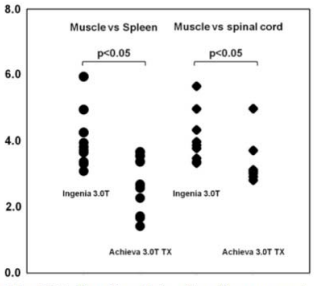

Fig.4 Relative signal intensity ratio compared to muscle in coronal DWI. Ingenia 3.0T showed significantly higher ratio.

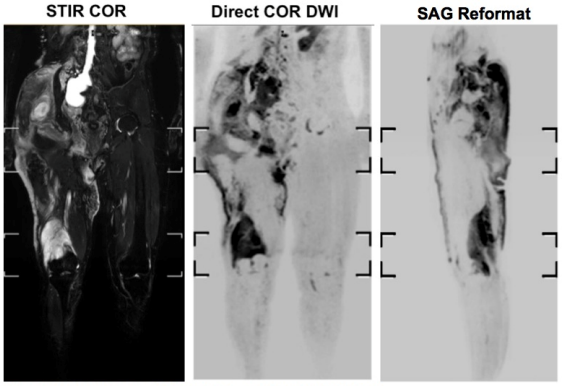

Fig.5 Comparison of Direct Coronal DWI to STIR
A 49 year-old woman with neurofibromatosis. Tumor distribution is well demonstrated with less distortion both in original coronal and reformatted sagittal images.