The Egyptian Journal of Radiology and Nuclear Medicine 49 (2018) 732–736

Contents lists available at ScienceDirect

The Egyptian Journal of Radiology and Nuclear Medicine

journal homepage: www.elsevier.com/locate/ejrnm

Original Article

The role of parallel imaging technique in decreasing geometric distortion artifact in diffusion weighted imaging of the brain

Mohamed M. Zaki[a], Ehab A. Hegazy[b,*], Maysa I. Abdelhamid[a], Sabry A. El-Mogy[c]

[a] Department of Physics, Faculty Science, Mansoura University, Egypt
[b] Department of Physics, Faculty of Engineering, Delta University, Egypt
[c] Department of Radio-diagnosis, Faculty of Medicine, Mansoura University, Egypt

ARTICLE INFO

Keywords:
EPI
DWI
Geometric distortion artifact
Parallel imaging technique

ABSTRACT

Introduction: The purpose of this study was to evaluate the role of parallel imaging technique in obtaining a more accurate geometric representation of the studied anatomy and how far this technique can reduce the pixel displacement and increase resolution in echo planner imaging- diffusion weighted (EPI-DW) images of the brain.
Patients & methods: The study was done on 6 patients, they were subjected to routine brain MRI examination for different symptoms, examination was done on 1.5 T scanner, the degree of geometric distortion was measured in the phase encoding direction (from anterior to posterior (A/P) in the used sequence) in both DWI sequence acquired without and with parallel imaging technique respectively and was compared with T2-FSE sequence which has no geometric distortion as in EPI.
Results: Parallel imaging technique reduced artifact (pixel displacement) in frontal and occipital lobes in addition to increasing resolution for EPI-DWI for the brain. This technique reduced pixel displacement in the frontal lobe by 47 ± 11.7% and 47.3 ± 11% reduction in the occipital lobe.
Conclusion: Parallel imaging technique can be used with EPI-DWI to increase resolution and decrease geometric distortion artifact to acquire more accurate geometric representation of the acquired anatomy.

1. Introduction

Diffusion weighted magnetic resonance imaging (DW-MRI) entered the clinical domain when manufacturers made Echo Planar Imaging (EPI) available on their MRI scanners [1]. Diffusion MRI is a non-invasive technique which helps quantify the microstructural characteristics of tissue by in-vivo mapping of diffusion processes [2]. It also changes with physiological or pathological states, which makes diffusion MRI a very powerful method [1,2]. MR signals can be made sensitive to diffusion through the use of a pair of sharp magnetic field gradient pulses, the duration and the separation of which can be adjusted [2].

EPI is the standard pulse sequence used in diffusion-weighted magnetic resonance imaging [3]. EPI is a popular fast imaging technique, but EPI images are well-known to have localized geometric distortions caused by inhomogeneities in the main magnetic field (B0) [4–7]. This distortion is most significant near the boundaries separating air, bone, and soft tissues, where there are large differences in magnetic susceptibility [7,8]. These distortions in the diffusion data can lead to misalignment with the anatomical images by several millimeters, which can limit the accuracy of image analysis in the affected regions [6,9,10]. The highest image distortion is seen in phase encoding direction which depends on phase-encoding steps [11]. The effect of field inhomogeneity is negligible in regular gradient echo and spin echo sampling strategies where one k-space line is acquired per phase encoding step, however, effect is significant in EPI [12].

Diffusion-weighted (DW) imaging has emerged as an immediate, quick, and robust means of visualizing pathological processes such as acute brain ischemia [4,13]. DWI normally has a low SNR (signal to noise ratio) especially for those anatomies that require high b values (diffusion gradient strength) (e.g., brain) [14]. This is because in EPI there is virtually no time at all for the flat top of the gradient waveform. Which cause signal loss and low resolution [15].

Some methods like field mapping and Periodically Rotated Overlapping Parallel Lines with Enhanced Reconstruction (PROPELLER) have been used to correct geometric distortion artifact, but there are noteworthy challenges to FSE-based methods in addition to long scan time (PROPELLER) and extra data needed for field mapping

Peer review under responsibility of The Egyptian Society of Radiology and Nuclear Medicine.
* Corresponding author.
E-mail address: ehabhegazy99@yahoo.com (E.A. Hegazy).

https://doi.org/10.1016/j.ejrnm.2018.05.009
Received 30 January 2018; Accepted 18 May 2018
Available online 10 July 2018

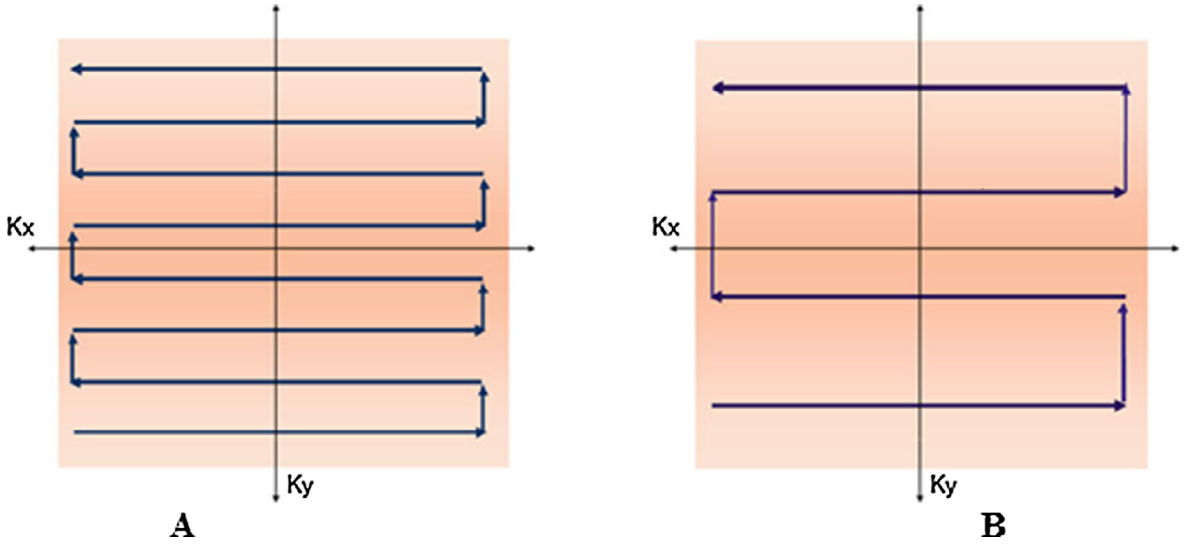

Fig. 1. Filling K- space by EPI. (A) conventional EPI, (B) with parallel imaging technique.

method [16,17,13].

Parallel imaging technique can only work with phased array coils, it uses the surface coils sited side by side for the simultaneous collecting data from many reduced areas. Using parallel imaging can decrease the scan time by decreasing the total steps of phase-encoding without using faster gradient switching rates (Fig. 1). The number of phase-encoding steps is decreased by incomplete sampling of k- space, replacing those non-acquired lines using the spatial information of the sensitivity maps of surface phased array coils. Parallel imaging strategy does not change the contrast features [18,19].

In parallel imaging, the acceleration factor defined as the factor by which lines in K-space to be reduced [19]. Using parallel imaging or ASSET (Array Spatial Sensitivity Encoding Technique) with EPI will reduce number of phase encoding gradient needed for completing all k-space lines, so, susceptibility will be reduced and pixel shift will be reduced providing a more accurate geometric representative of the studied anatomy. The advantage of this strategy is that, we don't need extra data acquisition, increasing scan time or affecting contrast features.

The purpose of this study was to evaluate the role of parallel imaging technique in obtaining a more accurate geometric representation of the studied anatomy and how far this technique can reduce the pixel displacement and increase resolution in EPI-DW images of the brain a method that neither need extra data nor extra time.

2. Patients and method

2.1. Patients

Six consecutive patients with normal MRI study were referred from Mansoura advanced radiology center, Mansoura city, Egypt. Four males and two females with age varying from 5 months to 58 years old through the duration of nine months. Other patients with any pathology were excluded.

2.2. MR examination

The MR imaging was performed using a 1.5 T scanner (signa, HDx, GE, Chicago, Illinois, USA) using high definition neuron vascular (HDNV) array 8 channel coil. Firstly, routine study was done: T2-FSE (TR/TE,4160/103 ms), T1-memp/75 (TR/TE,480/12 ms), T2 FLAIR (TR/TE/TI, 8002/123/2000 ms), and SE/EPI (DWI) (TR/TE, 11500/123).

DWI parameters are: b-value 1000 s/mm^2, diffusion direction all, frequency direction R/L, NEX 1, matrix 128 * 128 (voxel size 1.87 * 1.87 * 5 mm^3), scan time 0:58 min, and optimization TE technique.

All sequences acquired with the same field of view (FOV = 24 cm), the same slice thickness (5 mm), and the same slice spacing (1.5 mm), for patient with normal study, in addition to sequences above we duplicated the DWI sequence and only add the parallel imaging technique for comparing the resultant images with that one acquired without parallel imaging technique.

2.3. Image analysis

All images were translated via CD to a computer have a DICOM viewer program (http://www.radiantviewer.com) Fig. 2 which was used to compare DW-images before and after using the parallel imaging technique and for measurements of the degree of geometric distortion in DWI compared with T2-FSE (with no geometric distortion [6]).

The three sequence of interest axial (T2-FSE, DWI, DWI with parallel imaging technique) opened in the DICOM viewer respectively as seen in (Fig. 2). Firstly, normal anatomy and position measured on T2-FSE from anterior to posterior (A-P) using measurement tool in the viewer Fig. 3, then this measurement (red line) copied and pasted in both slices (B) and (C), then the displacement in the frontal lobe measured from the end of the red line to the end of the anatomy in the anterior region (green line) which represent the degree of pixel displacement from its normal position.

2.4. Statistical analysis

The reduction percentage for each case calculated from the equation

$$reductionpercentage = \left(\frac{DWI - DWI*}{DWI}\right) * 100$$

where DWI is the displacement in DWI acquired without ramp sampling, and DWI* is the displacement in DWI acquired with ramp sampling technique.

The results represented as the mean ± standard deviation (SD).

3. Results

Fig. 3 shows the same slice of brain acquired with different parameters (A) ax T2-FSE shows the normal anatomy of the brain without distortion artifact, (B) ax SE-EPI with DW parameters, (C) ax SE-EPI with DW parameters plus parallel imaging technique. It can be seen by