A New Fast Quality Assurance Tool for EPI-based Pulse Sequences

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INTRODUCTION

Geometric accuracy, minimal ghosting, temporal stability, and accurate fractional anisotropy measurements are critical in research echo-planar imaging (EPI) of the brain. Although EPI quality measurements are not part of the standard ACR annual MRI scanner evaluation, EPI quality assurance (QA) is critical for functional MRI [1] and quantitative diffusion tensor imaging. Manual ROI positioning and tabulation of results for EPI-QA is time-consuming and prone to human inconsistency. This abstract presents a new, fast, semi-automatic, EPI-QA tool that evaluates geometric distortion, ghosting, temporal stability, and fractional anisotropy (FA) of the standard vendor-supplied spherical phantom. The tool also makes a standard SNR measurement. Results from the first three months of use on two research scanners indicate that this method can identify potential problems that should cue further action.

METHODS

QA measurements were performed weekly for two Siemens Trio 3T scanners. Both sites used the body coil for RF transmission. One site used the 12-channel Siemens head coil for RF reception, the other used an 8-channel Invivo coil. Technologists at both sites landmarked the vendor-supplied spherical phantom on the cross hairs and centered the phantom in the coil. The signal to noise ratio (SNR) was measured using a standard T1-image subtraction technique [2]. Five scans were run to collect EPI data: an axial and sagittal EPI volume to measure geometric distortion and ghosting for the 3 sets of gradients, BOLD-EPI for 200 volumes to measure temporal stability [3] and 6-directions, b=0,1000 s/mm2 to measure the fractional anisotropy (FA) variation from zero [4].

The new EPI-QA tool was developed in MATLAB (R2011b), and one command with several arguments runs the script to perform all image processing and analysis. The automated steps are: 1) data are converted from DICOM format to the NifTi format using dcm2nii [5], and the MATLAB NifTi toolbox [6] is used to read necessary header information; 2) mean values from a central and a peripheral region of interest (ROI) are used to calculate SNR; 3) a central ROI in the FA map is used to calculate FA variation from zero; 4) temporal stability is calculated via the Weisskoff method [3]; 5) ghosting is calculated by finding the maximal signal in the background along the phase–encoding direction and averaging over a 4x4 pixel region around this maximum. The percentage ghosting is 100[(Ghost-Background)/(Signal –Background)]. 6) To visually inspect phantom positioning, ghosting, and distortion, the EPI images are automatically displayed at two window/level settings; 7) In the only step that includes user intervention, the user draws horizontal and vertical diameters on the central axial and sagittal EPI images for the geometric distortion calculation. The tool then automatically calculates the geometric distortion as a ratio of the two chosen diameters. Means and standard deviations for the first three months of use for each scanner were calculated from the EPI-QA tool output files. The automated ghosting calculations were compared to manual measurements of ghosting made using Osirix (v.3.9.4);

RESULTS

The automated QA check using this new tool takes less than 30 seconds. Means and standard deviations for SNR, FA, temporal stability, ghosting, and geometric distortion are reported in the table below. The automated ghosting measurements of 1.57% (12-channel) and 1.94% (8-channel) were higher than those made manually using the ROI, 1.25% and 1.02%, respectively. The automated ghosting calculation was consistently higher than the manual method, indicating that the automated method is sensitive enough to alert the user to a problem with ghosting.

Scanner Head Coil	SNR (Mean/STD)	FA (Mean/ STD)	%Temporal Stability (Mean/ STD)	%Ghosting (Mean/ STD)	GeometricDistortion (Mean/ STD)
12 channel	**35.2 / 1.8**	**0.034 / 0.012**	**0.24 / 0.09**	**1.57 / 0.31**	**1.02 / 0.02**
8 channel	**55.4 / 2.6**	**0.031 / 0.011**	**0.27 / 0.05**	**1.94 / 0.16**	**1.03 / 0.03**

CONCLUSIONS

This new EPI-QA tool enables fast EPI quality assurance (QA) evaluation that is critical for research-oriented functional MRI and quantitative diffusion tensor imaging. The speed and ease of use permits monitoring of ongoing problems as needed, and could easily be incorporated on a daily basis. This tool can be easily adapted for other sites with different scanners. In addition to these scanners, two additional external sites are piloting this method, and if the piloting is successful the tool could be made available to other interested investigators upon request.

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