

An accelerating method for FSE phase correction

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Introduction

FSE is characterized by a number of rapidly applied refocusing RF pulses and multiple echoes, altering the phase encoding gradient for each echo. The image quality of FSE is more sensitive to phase error caused by eddy current than typical spin echo pulse sequence. To eliminate the phase error, refocusing RF phase and readout gradient area is corrected before image data acquisition [1].

Typical phase correction method uses an iterative correcting approach to reduce the phase differences between odd and even echoes, which will cost 3 to 4 repetition times (TRs) [2].

Another method is retrospective phase correction. It collects non-phase encoded reference data, calculates phase coefficients, and then corrects the regular phase-encoded image dataset based on these coefficients. It is conducted after data acquisition [3]. This method will cost at least 1 TR to collect the reference data, and it can't coherently combine the signal from spin echo and stimulated echo to prevent destructive signal interference during image data acquisition.

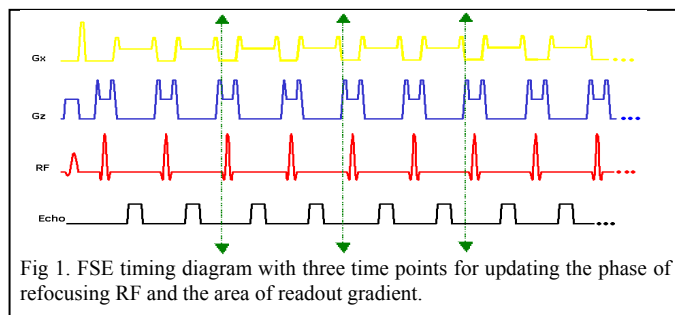
This abstract describes a method to reduce the data acquisition time for phase correction. It uses a real time system to update the refocusing RF phase and the readout gradient area.

Methods

The accelerating phase correction method can be described as following:

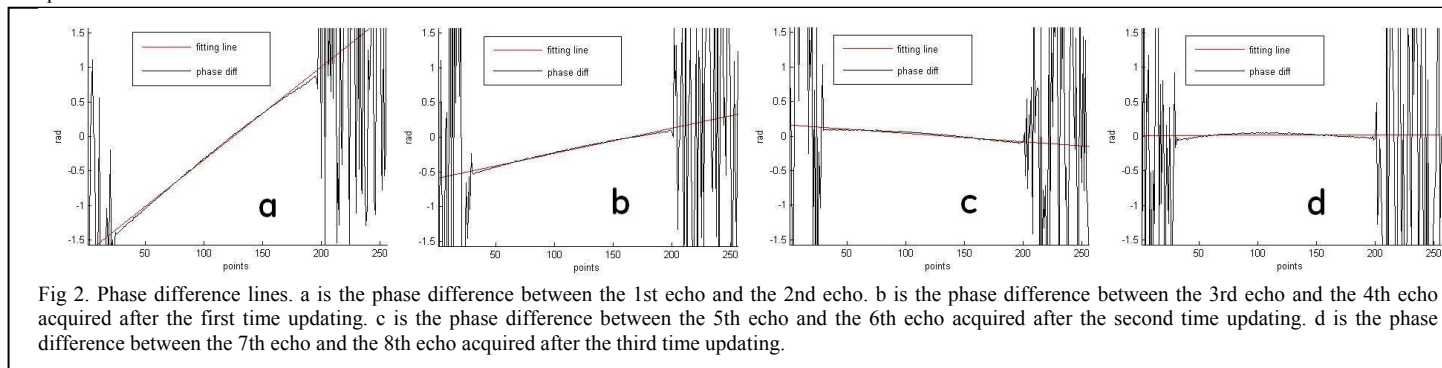
1. Start FSE pulse sequence without phase encoding.
2. Acquire the 1st echo and the 2nd echo.
3. Calculate phase difference between the two echoes.
4. Calculate the RF phase correction and the readout gradient area correction.
5. Update RF phase and readout gradient area by a real time system.
6. Continue running FSE with the updated RF and readout gradient area to acquire the following 2 echoes.
7. Repeat step3 to step6 until the phase difference is less than a preset value.

Fig 1 shows the timing diagram of FSE pulse sequence. 3 points of time are marked in the figure to update the refocusing RF phase and the readout gradient area through a real time system after acquiring the 2nd echo, 4th echo and 6th echo.



Results

This method is demonstrated on GE Optima MR360 1.5T system step by step. In order to show the phase correction effect, the eddy current compensation on the system was removed. The phase difference between 2 echoes is shown in Fig 2. The phase difference between the 7th echo and the 8th echo is less than the preset value. The phase correction is finished within 1 shot.



The correction result is shown in Fig3. It is the phase difference between the 1st echo and the 2nd echo. They are acquired with corrected refocusing RF phase and corrected readout gradient area. The result is less than the preset value, which mean that the accelerating phase correction method work well and efficient.

The new method compresses 4 shots acquisition into 1 shot for phase correction, which saves time by 3 TRs. In general, it can accelerate the phase correction iteration as etl/2 factor. 'etl' stands for echo train length. The correction result is comparable to the traditional correction method.

Discussion

The stimulated echo effect must be considered because of the existing eddy current and tailed RF usually applied for FSE. To retire this problem, two methods can be applied. One is turning off tailed RF when doing phase correction. This change will not affect the correction result because it will not change the gradient waveform and the phase of RF. Another one is using crusher gradient on phase encoding direction when doing phase correction. This method is very efficient to kill the stimulated echo. But it would lose a little phase correction precision because the crusher gradient will introduce additional eddy current.

References

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