Dynamic Shimming at 7 Tesla

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Introduction

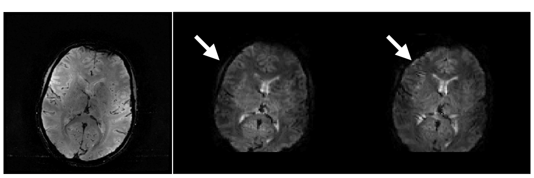
Dynamic Shimming is a technique for obtaining optimal Bo field homogeneity over a volume by updating the shim coil and gradient currents for every slice in a multislice acquisition in real time [1, 2]. Dynamic shimming can produce better field homogeneity within each slice than global volume shimming methods. It can therefore reduce signal losses and geometric distortions due to variations in magnetic susceptibility within the body, and can be especially useful in fast T_2* weighted imaging sequences such as EPI and in multislice spectroscopic imaging. We have implemented dynamic shimming on a human 7T system. Initial results with human brain imaging and an evaluation of the improvements made, are presented.

Methods

Our studies were performed on a Philips 7Tesla Achieva human imaging system based on a Magnex 90 cm. bore magnet. For the 1st order slicewise corrections, modifications were made to the shimming pulse program software. For the higher order corrections, an additional hardware module (MXH -14R Real Time Shim System, RTS, Resonance Research Inc, MA, USA) was connected to the auxiliary input of the higher (2nd and 3rd) order shim supplies. This module was triggered by the pulse program at appropriate times to load the correct shim values. Phantom and human studies were performed to demonstrate the effects of dynamic shimming. 64x64 pixel resolution field maps were acquired for the slices of interest and analyzed using a least squares algorithm in Matlab 7.0 to obtain the shim corrections for individual slices. These were then ported back to the scanner console computer and also used to preload the RTS system, along with the proposed scan parameters. During scanning, the 1st order corrections were loaded slice wise through the gradient controls and the 2nd order shims were loaded from the RTS system triggered by the pulse program. Slice wise base frequency correction was also implemented to correct for shim induced frequency offset changes. Results were compared with the existing pencil beam based global shimming method available on the scanner for FFE and EPI images.

Results and Discussion

Fig 1a shows axial slice human results of 2nd order dynamic shimming (DS2) compared to pencil beam shimming (HS2) and no shimming (NS). The static field standard deviations across the brain in all five image slices were significantly lower with DS2 than with HS2. This improvement in B0 homogeneity was reflected in reduced signal drop-out and lower image distortion with DS2 compared with HS2 (arrows in Fig 1b, Fig 2). Current work is focused on optimizing the procedure and characterizing its effects including eddy currents, the importance of 3rd order shims and the influence of fieldmap acquisition method. Future work will involve integrating dynamic shimming into regular anatomic and functional imaging and spectroscopy as well as incorporating real time B0 field sampling and dynamic shim correction.



FFE Dynamic Shim Global Shim

Fig 2: Distortion in EPI images improved with dynamic shimming
Left –Right: FFE, EPI with Dynamic shim, EPI with Global Shim

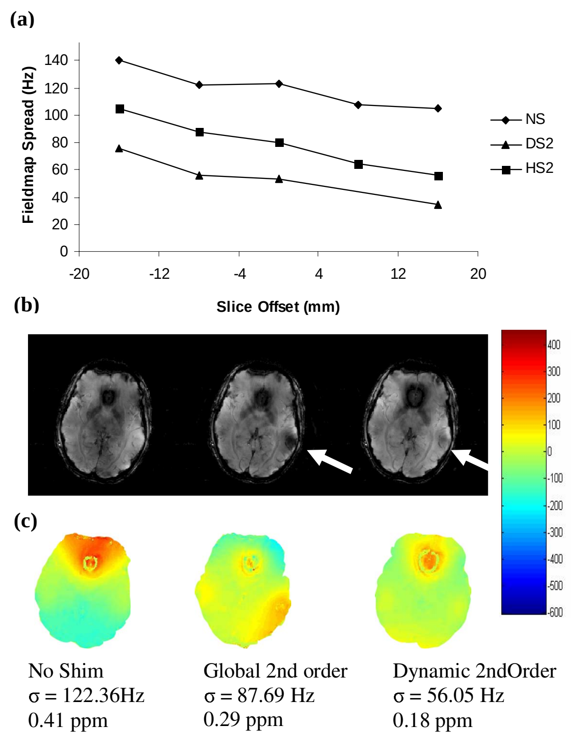


Fig 1: Dynamic Shim results (a) Fieldmap spreads in Hz (b) Slice 3 FFE images (c) Slice 3 Fieldmaps in Hz.

Conclusions

Dynamic shimming has been implemented on a human 7T scanner and is shown to be a promising approach for tackling the effects of inhomogeneities inherent in using high field strength magnets.

Reference

[1] Blamire AM et al, Magn Reson. Med. 36:159, 1996. [2] Zhao Y et al, J of Magn Reson, 173, 10-22, 2005