Improved Shim by Subject Head Positioning

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Introduction

A large susceptability artifact arises from the air-tissue interface of the nasal cavity in the head. This region of large susceptability difference creates field distortions that typically cannot be corrected by shimming. For example, it is difficult to obtain proton NMR spectra from the inferior frontal lobe of the brain, whether by spectroscopic imaging (SI) or single voxel techniques (SVS). Often data from regions of the inferior frontal lobe in SI must be discarded due to the large field inhomogeneity near the sinus, as shown in ref [1]. Recently the static magnetic field numerically derived in a human head model by solving the field equations with finite element analysis on a discretized model of the head was found to agree well with actual field maps obtained in human volunteers. [2] A salient result of that study was the character of the nasal cavity field distortion. It was found that a region of high field is located above the nasal cavity and a region of low field is found behind the nasal cavity. Since these field effects are dependent on the direction of the main magnetic field relative to the head, it is possible to direct the distortions away from the inferior frontal lobe as proposed by M.B. Smith [3]. This abstract will present experimental evidence of the utility of this simple positioning method for acquiring para-axial slices traversing the anterior commisure (AC) and the posterior commisure (PC) in the human head.

Methods

All experiments were performed on a 1.5T Siemens Vision clinical scanner. Two experimental protocols were used. The first is a shimming session performed on 10 different subjects and the second is a field mapping experiment performed on one subject. The shimming data is taken from a previous spectroscopic imaging study, where the protocol uses a manual shimming session on a slab traversing the AC-PC. After automatic global shimming, shim currents are manually optimized to reduce the FWHM of the slice specific water peak. The FWHM of the best shim achieved is recorded. The angle of the plane through the AC-PC relative to the main magnetic field is also recorded. The second experiment maps the static magnetic field in a single subject with three different head positions. The field mapping is performed using two gradient echo imaging sequences with different echo times. The sequence parameters are a TR of 178ms, TE's of 10ms and 23ms, a 240mm FOV, a 128x128 matrix, and NEX 2. A single 10mm slice is positioned traversing the anterior and posterior commisures. The field map is calculated by unwrapping the phase difference map obtained from the two images.

Results

Plotting the FWHM of the resulting shim versus the tilt angle of the head in the magnet reveals a trend in the data (Fig. 1). As the angle increases, which is equivalent to tilting the head back while the subject is laying supine in the scanner, the shim improves. In the figure a tilt angle of zero degrees means that the AC-PC plane is directly perpendicular to the main magnetic field. To examine this trend in more detail, profiles of the field map obtained in one subject are plotted in Fig. 2. These profiles are from the same subject with three different head positions and are taken in the posterior-anterior direction. The high field distortion in the zero degree tilt profile diminishes as the the head tilts back. Also, a slight negative field distortion is evident in the thirty degree tilt profile.

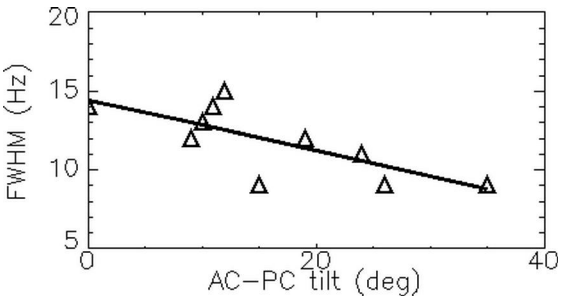

Figure 1. FWHM of the water peak for slab shims in 10 subjects with varying head positions.

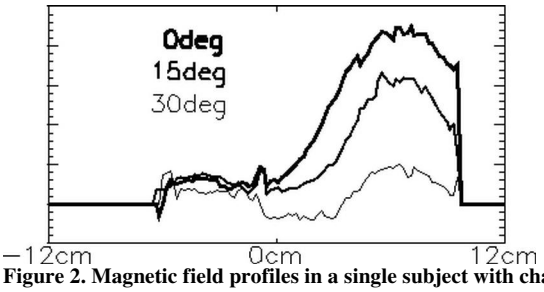

Figure 2. Magnetic field profiles in a single subject with changing head position. The profiles are taken posterior (left) to anterior (right) and are anatomically registered.

Discussion

The susceptability artifact caused by the nasal cavity is a problem common to many advanced MR techniques. In general the inferior frontal lobe is problematic as a result. The simple head positioning procedure described in the current work improves the shim in this area. The desirable head position can be obtained by using minimal padding for the back of the head and increasing the padding slightly near the base of the neck.

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References

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