Shimming of the Inferior Frontal Cortex using an External Local Shim Coil

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Introduction

For T2* weighted imaging techniques such as those commonly used to obtain BOLD contrast, susceptibility related magnetic field inhomogeneity can generate image artifacts including signal dropout, blurring, and distortion. Inhomogeneities in some areas of the brain such as the inferior frontal cortex (IFC) are particularly problematic, as they are large and of spatial order that is far too high to correct using low order whole body shim coils. To reduce field inhomogeneity in the IFC, intra-oral pyrolytic graphite has been used with success as a passive diamagnetic shim (1), and more recently, an intra-oral active shim coil has been used with similar effect (2). Advantages of the active shim coil include: 1) potential for remote and dynamic adjustment, 2) smaller size, 3) adjustable field patterns, and 4) potential for multiple shim channels. A disadvantage of both intra-oral shim techniques is that the presence of an intra-oral device can be uncomfortable, and may reduce patient/subject compliance. We introduce here the use of an external coil to shim the fields in the IFC.

Methods

The local shim coil used in this study was made of 14 turns of 16G magnet wire wound into a disk that is 2 layers thick, with inner diameter 18mm and outer diameter 36mm. The coil was driven using a DC current supply, requiring less than 1V to supply 0-2A of current. Two positions were used for the coil, an intra-oral position as in (2), and an external position over the nose with the plane of the coil approximately 20° from the axis of the magnet. Both coil positions are shown in Figure 1A. Figure 1B shows a field map in the mid-saggital plane for a normal volunteer. Figures 1C and 1D show the calculated fields from the local shim coil added to the measured fields. The presence of either coils improves the calculated fields in the IFC to approximately the same degree, but with slightly different distribution.

Single shot EPI images were acquired on a Varian 3T scanner with FOV 256mm x 5mm, 64x64 matrix in the axial plane, with and without the local shim coils. Using real-time EPI images for feedback and a reduction of the signal dropout in the IFC as the criterion, the optimal current was empirically found to be 1.6A for the intra-oral coil, and 1.0A for the external coil.

Results

Figure 2 shows multislice axial EPI images acquired without the local coil, and with the local coil in both positions. Both coils effect a significant recovery of signal in the IFC (red lines). Note also that the intra-oral coil causes additional signal dropout in the anterior portions of the temporal lobes while the external coil does not (yellow lines).

Discussion

A local shim coil located in front of the nose is as effective at reducing susceptibility related signal dropout in the IFC as an intra-oral coil. The external coil allows for local shimming of the IFC without placing anything in the mouth of the subject. In addition, the external coil preserves signal in the anterior temporal lobes.

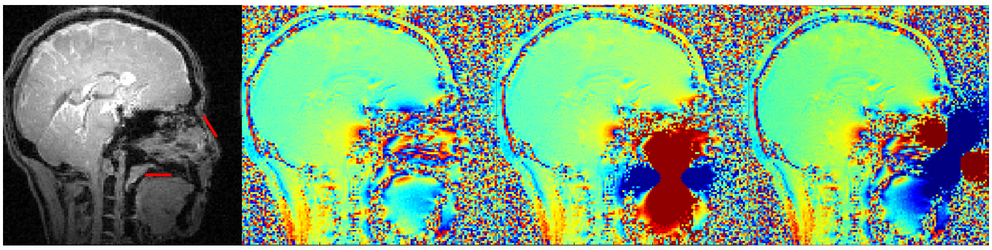

Figure 1. A: Shim coil locations B-D: Field maps with: no local shim, intra-oral shim, shim over nose.

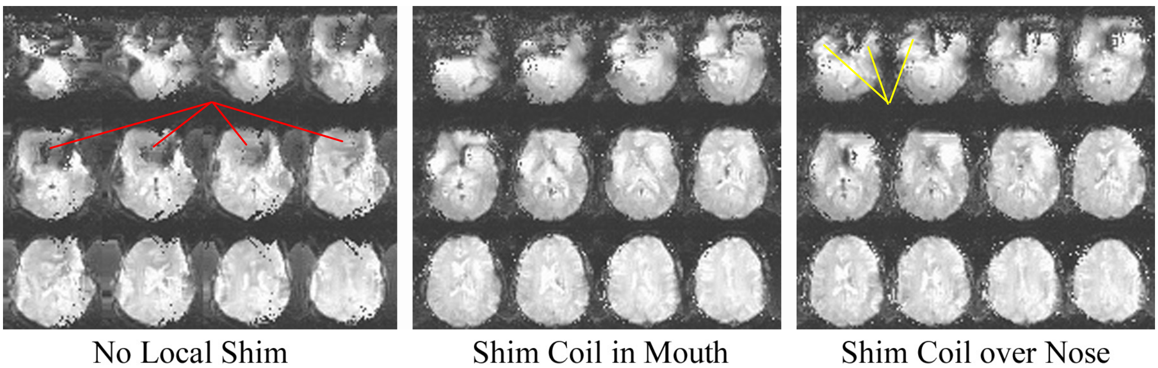

Figure 2. Multislice single shot EPI with different shim coil configurations.

References

1. Wilson et al. MRM 48, p.906, 2002.
2. Hsu et al. ISMRM abstracts, p.734, 2003.